SOVEREIGN UNCERTAINTY

2024

BANCO DE ESPAÑA
Eurosistema

Documentos de Trabajo
N.º 2423

Edgar Silgado-Gómez

SOVEREIGN UNCERTAINTY [*]

Edgar Silgado-Gómez [**]

BANCO DE ESPAÑA

(*) Acknowledgments: I am grateful to Pierpaolo Benigno, Pablo Burriel, Silvia Calò, Efrem Castelnuovo, Daragh Clancy, Luisa Corrado, Jesús Fernández-Villaverde, Matija Lozej, Salvatore Nisticò, Gerard O'Reilly, Javier J. Pérez, Tommaso Proietti, anonymous referees and seminar participants at the Banco de España, European Central Bank, EEA-ESEM, Central Bank of Ireland, Banque Centrale de Luxembourg, Rome Tor Vergata, XXVIII Encuentro de Economía Pública and Latvijas Banka for their useful comments and discussions.
(**) edgar.silgado@bde.es.

Documentos de Trabajo. N.º 2423

July 2024

https://doi.org/10.53479/36875

The Working Paper Series seeks to disseminate original research in economics and finance. All papers have been anonymously refereed. By publishing these papers, the Banco de España aims to contribute to economic analysis and, in particular, to knowledge of the Spanish economy and its international environment.

The opinions and analyses in the Working Paper Series are the responsibility of the authors and, therefore, do not necessarily coincide with those of the Banco de España or the Eurosystem.

The Banco de España disseminates its main reports and most of its publications via the Internet at the following website: http://www.bde.es.

ISSN: 1579-8666 (on line)

Abstract

This paper investigates the impact and the transmission of uncertainty regarding the future path of government finances on economic activity. I first employ a data-rich approach to extract a novel proxy that captures uncertainty surrounding public finances, which I refer to as sovereign uncertainty, and demonstrate that the estimated measure exhibits distinct fluctuations from macro-financial and economic policy uncertainty indices. Next, I analyse the behaviour of sovereign uncertainty shocks and detect the presence of significant and long-lasting negative effects in the financial and macroeconomic sectors using state-of-the-art identification strategies, within the context of a Bayesian vector autoregression framework. I show that a shock to sovereign uncertainty differs from a macro-financial uncertainty shock originating from disturbances in the private sector — while the former persistently dampens the economy in the medium run, the latter displays a short-lived response in real activity. Lastly, I study the role of sovereign uncertainty in a New Keynesian dynamic stochastic general equilibrium model augmented with recursive preferences and financial intermediaries. I find that a sovereign uncertainty shock in the model is able to capture the empirical slowdowns in economic aggregates if monetary policy decisions are directly influenced by the shock. The model also emphasizes the importance of financial frictions in transmitting the effects of sovereign uncertainty shocks and highlights the minor role played by nominal rigidities.

Keywords: sovereign uncertainty index, government finances, economic activity, event-based identification, Bayesian VARs, non-linear DSGE models.

JEL classification: C32, E32, E44, E60.

Resumen

Este trabajo investiga el impacto y la transmisión de la incertidumbre en torno a la senda futura de las finanzas públicas sobre la actividad económica. En primer lugar, se emplea un enfoque rico en datos para extraer un nuevo indicador que captura la incertidumbre en torno a las finanzas públicas, al que se denomina «incertidumbre soberana», y se demuestra que la medida estimada presenta fluctuaciones diferentes con respecto a los índices de incertidumbre macrofinancieros y de política económica. A continuación, se analiza el comportamiento de las perturbaciones de incertidumbre soberana y se detecta la presencia de efectos negativos significativos y persistentes en los sectores financieros y macroeconómicos mediante la utilización de métodos de identificación de vanguardia, dentro del contexto de los modelos autorregresivos bayesianos. Se demuestra que una perturbación de incertidumbre soberana produce unos efectos diferentes a los generados por una perturbación de incertidumbre macrofinanciera que se origina en el sector privado —mientras que la primera afecta persistentemente a la economía a medio plazo, la segunda muestra una respuesta de corta duración en la actividad real—. Finalmente, se estudia el papel de la incertidumbre soberana en un modelo neokeynesiano de equilibrio general dinámico y estocástico ampliado con preferencias recursivas e intermediarios financieros. Se encuentra que una perturbación de incertidumbre soberana en el modelo es capaz de capturar los efectos empíricos si las decisiones de política monetaria están directamente influidas por la perturbación. El modelo también destaca la importancia de las fricciones financieras en la transmisión de los efectos de las perturbaciones de incertidumbre soberana y resalta el menor papel desempeñado por las rigideces nominales.

Palabras clave: índice de incertidumbre soberana, finanzas públicas, actividad económica, identificación basada en eventos, VAR bayesiano, modelos DSGE no lineales.

Códigos JEL: C32, E32, E44, E60.

1 Introduction

Since the aftermath of the Great Recession, the solvency of several European governments has again become the focus of attention among economists and policymakers. This situation has resulted in an increase in uncertainty about the outlook for public finances. For example, during the height of the sovereign debt crisis, Spain, Ireland, Portugal and Greece had to implement unprecedented economic programs in order to alleviate large fluctuations of the bond yield spreads, the high structural deficits and the considerable levels of debt. While a large and growing body of literature has focused on the consequences of overall uncertainty in business cycle fluctuations, evidence on the effects of uncertainty originating from disturbances in the public finances has received less discussion.[1]

In this paper, I contribute to the analysis of the transmission of uncertainty associated with government policy on economic activity. Firstly, I propose a new uncertainty indicator for public finances, which I refer to as *sovereign uncertainty*, by exploiting the high-information content of the forecasting methodology in Jurado et al. (2015). The benefit of using this framework is that changes in sovereign uncertainty capture whether the outlook for government finances has become more or less predictable, and not whether it has become more or less volatile. Moreover, in this approach sovereign uncertainty is a measure of the common variation in uncertainty across a large number of series that affect several aspects of the public finances simultaneously. Secondly, I employ Bayesian vector autoregression (BVAR) techniques to analyze the effects of sovereign uncertainty shocks on key macroeconomic and financial aggregates. These are identified through various identification strategies — recursive schemes and a combination of sign, event-based and ratio restrictions. Finally, I introduce an approximation for sovereign uncertainty in a New Keynesian dynamic stochastic general equilibrium (NK-DSGE) model with recursive preferences and financial intermediaries to rationalize the empirical results.

I conduct this study using Spanish data. In fact, Spain is an economy where the lack of discipline in public finances has been a longstanding issue (see BdE, 2006) and, therefore, the sovereign debt crisis was likely not a unique instance of concern regarding government uncertainty.[2] In order to obtain the sovereign uncertainty index, I use a sample of 31 government-related variables and 87 macro-financial time series. In particular, the former dataset embodies series on bond rates, securities, loans, revenues, expenditures and taxation. The macro-financial series encompass data on industrial production, prices, foreign trade, wages, raw materials, surveys, interest rates, exchange rates, credit and private equities. I use the combined datasets to estimate the forecasting model, but calculate sovereign uncertainty only from the aggregation of each individual uncertainty estimate associated with the public finance series. Sovereign uncertainty is then defined as an aggregate proxy that conveys a set of 31 government-related individual uncertainty indices from May 1997 to December 2019.

The estimated measure of sovereign uncertainty, denoted SU subsequently, identifies important government-related events for the Spanish economy. The most important are

[1] Bloom (2014), Fernández-Villaverde and Guerrón-Quintana (2020) and Castelnuovo (2023) are recent surveys on the role played by uncertainty in business cycle fluctuations.

[2] Other economies such as Greece or Italy are also informative cases of public uncertainty in recent times. However, in comparison with Spain, lack of (*i*) a large enough number of government finances indicators and (*ii*) a long time-span makes the choice of these countries questionable.

those related to the concerns prior to joining the European monetary union; the Spanish involvement in Iraq, which implied the use of a sizable amount of public resources to finance the military intervention; the global financial crisis; the Euro Area debt crisis; and the upward trend in sovereign uncertainty from 2015 to 2017, associated with political uncertainty given the difficulties of forming a stable government after two consecutive elections and, consequently, this entailed a freeze in the budget. Furthermore, I show that SU clearly exhibits independent variations from the economic policy uncertainty (EPU) indicator developed by Baker et al. (2016), as well as from macro-financial uncertainty (MU) originating from disturbances in the private sector, computed again with the Jurado et al. (2015) approach.[3] The difference between the SU index and both the EPU and MU is sizable. The correlation between SU and EPU is only 0.06 for the full sample. This divergence may arise either from the fact that coverage of political events has not always resulted in increased difficulty to predict the path of government finances, or from the fact that EPU does not explicitly control for a deterioration in expectations of the mean economic outcome when volatility increases, potentially conflating uncertainty shocks and confidence shocks. On the other hand, while SU and MU present a common spike at the height of the Great Recession, MU does not display any other episodes of heightened uncertainty captured by SU.

Next, according to my BVAR analysis, shocks to sovereign uncertainty that are identified through both recursive orderings and a combination of sign, event-based and ratio restrictions lead to economically and statistically significant declines in economic activity, and point to deflationary pressures. First, relative to the recursive identification, I argue under which conditions SU shocks can be considered as unable to contemporaneously respond to developments in the economy and vice versa, showing that the results are robust in both circumstances and, additionally, to an extensive battery of recursive-based robustness checks. Second, the mix of sign, event-based and ratio restrictions confirms, in general, the validity of the previous findings. In this case, I jointly identify a sovereign uncertainty shock and a macro-financial uncertainty shock. An interesting finding here is that the effects of these two sources of uncertainty are different — while SU shocks persistently perturb the economy in the medium-run, the impact of MU shocks on real activity is short-lived. Again, I check the robustness of these results by considering other prior beliefs about the narrative of both shocks and accounting for potential omitted variables in the baseline vector of agents' information.

In the theoretical section of the paper, the starting point is a canonical New Keynesian DSGE model augmented with financial intermediation as in Gertler and Karadi (2013) and Epstein-Zin (EZ) preferences. In the extended framework, banks hold government bonds. I explicitly model the real interest rate on these bonds as the sum of return on a perpetuity and an exogenous additive term which is subject to a stochastic volatility shock. The latter is an approximation of a sovereign uncertainty shock. This interpretation follows the extraction of the empirical measure of sovereign uncertainty where the time-varying volatility components are computed by employing an AR(1) stochastic volatility model. Hence, the way I model uncertainty in both parts of the paper is based on the same assumptions. This also allows for a shock to the second moment that is independent

[3] Meinen and Röehe (2017) and Redl (2018) already compute a measure of (overall) macroeconomic uncertainty for Spain and other European countries. I compute it here (given my macro-financial dataset) for comparative reasons, particularly, to show that sovereign uncertainty displays autonomous fluctuations from macro-financial uncertainty arising from disruptions in the private sector.

of the first moment. In addition, the model is solved by a third-order perturbation method (see Fernández-Villaverde et al., 2011 and Basu and Bundick, 2017) and estimated by matching model's moments with corresponding moments from the data.

The main finding here is that the proposed theoretical model captures the empirical slowdown in output, investment and hours worked following a SU shock and, in a lower proportion, it also accounts for the decline in consumption and bank lending while being consistent with the data moments and the empirical path of sovereign uncertainty after the shock. I also find that lack of reaction by the monetary authority when a SU shock hits the economy is crucial to fully reconcile, in magnitude, empirics with theory. One interpretation of the empirical results in the DSGE model is that, after a SU shock, the price of government bonds decline as it now becomes riskier to hold them as banks are exposed to larger fluctuations in the real return on government bonds (either negative or positive). At the same time, heightened sovereign uncertainty affects banks' expectations on firms' claims also causing a fall in the relative price of private capital. The drop in asset prices pulls down bank net worth. Consequently, banks' ability to lend to firms is severely limited since their credit capacity is directly tied to their net worth. Therefore, lack of sufficient bank credit creates scarcity of capital for firms and restricts real economic activity. Moreover, this theoretical framework emphasizes the importance of financial frictions in explaining and transmitting the effects of sovereign uncertainty shocks and highlights the minor role played by nominal rigidities.

My paper relates to several strands of literature. Empirically, I build on the insights of Jurado et al. (2015) and apply their ideas to the measurement of sovereign uncertainty. Born and Pfeifer (2014), Fernández-Villaverde et al. (2015) and Mumtaz and Surico (2018) analyze the effects of second-moment shocks to fiscal and monetary policy, generally finding moderately negative impact on economic activity.[4] In particular, Born and Pfeifer (2014) show that effects of uncertainty about future tax liabilities, government spending, and monetary policy are limited because their shocks are small and lack sufficiently persistency, whereas Fernández-Villaverde et al. (2015) report that only a two standard deviation fiscal volatility shock to the capital income tax rate is able to generate a relevant economic impact. Mumtaz and Surico (2018) argue that solely uncertainty about government debt has significant impact on real activity. A crucial difference with respect to these papers is that my government-related uncertainty measure is based on a high-information content approach and therefore, is intended to capture several aspects of the public finances simultaneously. In fact, the exclusion of this feature could potentially be the reason behind the minor role that their policy uncertainty shocks play in business cycle fluctuations. Another example focusing on policy uncertainty is Baker et al. (2016). In this influential work, the authors exploit information contained in newspapers to extract aggregate and policy-specific uncertainty indices for the U.S., as well as aggregate policy uncertainty measures for 11 other countries, and note a large detrimental impact of economic policy uncertainty. However, as argued before, their approach does not control for a worsening in expectations of the mean economic outcome when volatility rises, possibly combining confidence shocks (first moment) and uncertainty shocks (second moment).

On the theoretical side, this paper first speaks to a large body of literature examining the effects of uncertainty on the macroeconomy. In his seminal article, Bloom (2009)

[4] See also Mumtaz and Zanetti (2013), which preceded the study of Mumtaz and Surico (2018) and formed the basis of it.

demonstrates through building a model with time-varying second moments that uncertainty shocks generate sharp recessions and recoveries. Fernández-Villaverde et al. (2011) show why an increase in the volatility of the real interest rate at which emerging economies borrow can result in important drops in macroeconomic aggregates. Leduc and Liu (2016) and Basu and Bundick (2017), as well as Born and Pfeifer (2014) and Fernández-Villaverde et al. (2015), contribute to this theoretical literature by investigating the channels under which uncertainty shocks propagate into a New Keynesian economy without financial intermediaries. Regarding the inclusion of a banking sector, several authors are also concerned with the magnifying effects of financial frictions on the real economy after the occurrence of an uncertainty shock, including Christiano et al. (2014), Gilchrist et al. (2014) and Bonciani and van Roye (2016). However, I focus on the transmission of uncertainty about the outlook for public finances and the previous studies investigate the pass-through of overall uncertainty shocks under different banking frameworks.

Finally, this work also links to several theoretical papers in the literature on sovereign default risk (see Uribe, 2006; Arellano, 2008; and Bi, 2012). The closest study related to my theoretical section is Bocola (2016). He examines the effects of shocks to (perceived) sovereign default risk on economic activity through financial intermediaries. In particular, he analyzes two different but complementary channels (liquidity and risk) under which a rise in the probability of default transmits into the financial and real sectors of the Italian economy. In contrast, I do not focus on the probability of default; instead, I distinguish between first and second moment shocks via stochastic volatility (consistent with my empirical section). Second, the main objective of my theoretical exercise is to show whether a New Keynesian DSGE model with financial intermediation can effectively match the empirical evidence of an uncertainty shock originating from changes in the public financial sector, and if so, what are the important theoretical assumptions to achieve it. A third reason, is that the probability of default is normally just modelled subject to the level of debt in this theoretical literature. On the contrary, this study aims to capture many aspects of the solvency of a government and can be then used as an empirical test in the analysis on the adverse effects of governments' exposure to risks.

The remainder of the paper is structured as follows. Section 2 describes how to extract the uncertainty indicator for public finances. Section 3 analyzes the effects of the identified sovereign uncertainty shocks through recursive schemes and a combination of sign, event-based and ratio restrictions in a BVAR framework. Section 4 contains a NK-DSGE model with recursive preferences and financial intermediaries to rationalize the empirical results. Section 5 concludes.

2 Measuring Sovereign Uncertainty

To study the transmission of uncertainty surrounding the public finances of the Spanish economy, I first define and compute a novel measure by means of a data-rich approach. In particular, I define a sovereign uncertainty (SU) index as an aggregate proxy that conveys a large set of government-related individual uncertainty indices. These are computed based on the econometric methodology in Jurado et al. (2015). The benefit of using this method is that changes in uncertainty capture whether economic conditions have become more or less predictable, and not whether they have become more or less volatile. This framework implies that any type of uncertainty (e.g. macroeconomic, financial or trade) is not equal to uncertainty in any single time series, but requires the existence of a common variation in uncertainty across a large number of time series. Moreover, common variation in uncertainty is critical because if the variability of an idiosyncratic shock was purely idiosyncratic, it would have no impact on macroeconomic developments. Accordingly, a measure of sovereign uncertainty would also need to entail uncertainty fluctuations that affect several aspects of the public finances of a government at the same time.[5] In what follows, I present a brief description of the key equations. For further details, I refer the reader to Jurado et al. (2015) and references cited therein.

2.1 Econometric Approach

Formally, let $E[y_{j,t+1}|I_t]$ be a forecast for each individual time series included in the following factor augmented forecasting model:

$$y_{j,t+1} = \phi_j^y(L)y_{j,t} + \gamma_j^F(L)\hat{F}_t + \gamma_j^G(L)\hat{G}_t + \gamma_j^W(L)W_t + \nu_{j,t+1}^y, \tag{1}$$

where $\phi_j^y(L)$, $\gamma_j^F(L)$, $\gamma_j^G(L)$ and $\gamma_j^W(L)$ are finite-order polynomials; F_t is a set of potential factors drawn from the original data set; G_t entails a set of potential factors drawn from the squares of the original data set; and W_t is comprised of squares of the first principal component in F_t. The selected factors $\hat{F}_t$ and $\hat{G}_t$ are based on their incremental predictive power for each $y_{j,t}$ by using the information criterion in Bai and Ng (2002).[6]

The one-step-ahead prediction error of $y_{j,t+1}$ and of each selected factor exhibits time-varying volatility. For each forecast error, time-varying volatility is computed by employing an AR(1) stochastic volatility model which allows for a shock to the second moment that is independent of the first moment, consistent with theoretical models of uncertainty (see Fernández-Villaverde et al., 2011; Born and Pfeifer, 2014; Fernández-Villaverde et al., 2015; and Basu and Bundick, 2017). Then, uncertainty associated with the variable $y_{j,t}$ at forecast horizon h, denoted as $\mathbb{U}_{j,t}(h)$, is defined as the conditional volatility of its purely unforecastable component of the future value of the series:

$$\mathbb{U}_{j,t}(h) = \sqrt{\mathbb{E}\left[(y_{j,t+h} - \mathbb{E}[y_{j,t+h}|I_t])^2|I_t\right]}, \tag{2}$$

where the expectation $\mathbb{E}(\cdot|I_t)$ is taken with respect to the information I_t available to economic agents at time t. If the expectation today of the squared forecast error rises, uncertainty in the variable increases. As my sovereign uncertainty proxy is a measure of the common variation in uncertainty across many time series related with the Spanish public finances, the index is then constructed by taking an average of $\mathbb{U}_{j,t}(h)$ across all time series:

$$\mathbb{U}_t(h) \equiv plim_{N\to\infty} \sum_{j=1}^{N} \frac{1}{N}\mathbb{U}_{j,t}(h). \tag{3}$$

This is based on equally weighting the individual uncertainty estimates.

[5] It is important to remark that sovereign uncertainty is not the same as disagreement about future fiscal policy. A good example is Ricco et al. (2016). Their disagreement measure based on professional survey forecasts may reflect differences in opinion rather than of uncertainty. In fact, they show that their measure does not correlate with the aggregate index of Baker et al. (2016) or with its individual sub-components.

[6] Bai and Ng (2002) propose a t-test with a threshold value of $t = 2.575$.

2.2 Dataset

I apply the previous framework to Spain using a sample of 31 government-related variables and 87 macro-financial time series. I use the combined dataset to estimate the forecasting factors, but calculate sovereign uncertainty only from the individual uncertainties in the public sector time series. I have conducted further investigations (results available upon request) and find that the estimated sovereign uncertainty indicator does not significantly change with or without including the macro-financial dataset in the forecasting model. Yet, I opt for including it since this provides an estimate of macro-financial uncertainty (MU) arising from disruptions in the private sector that I can directly compare with the SU index, and study the differences and similarities of both measures.

I employ monthly data from January 1997 to December 2019 (I also consider an extension that includes the COVID-19 pandemic up to April 2022). The datasets cover a broad spectrum of series: (*i*) the government-related dataset embodies series on bond rates, securities, loans, revenues, expenditures and taxation, for different maturities and owners where appropriate; (*ii*) the macro-financial series encompass data on industrial production, prices, foreign trade, wages, raw materials, surveys, interest rates, exchange rates, credit and private equities. All data are fetched from the Statistical Data Warehouse (SDW), Haver Analytics or Datastream.[7] In general, interest rates and exchange rates are used as levels, survey data is transformed into first differences, and for all other series first (log) differences are applied. A detailed description of data sources and definitions is listed in Appendix A.1.

2.3 An Estimate for Sovereign Uncertainty

Figure 1 depicts the estimated one-month ahead measure of sovereign uncertainty.[8,9] It can be observed that the proxy matches important government-related events for the Spanish economy:

- Prior to joining the European monetary union (EMU), Spain faced a period of sovereign uncertainty (which in fact was not captured by macro-financial uncertainty). At this time, there were concerns about the success of the monetary integration, in particular for economies with weak tradition of macroeconomic discipline (see BdE, 2006).

[7] There are few exceptions. See Appendix A.1 for further details.

[8] I have verified that the sovereign uncertainty index remains unchanged when substituting government bond rates at different maturities for their spreads (with respect to Germany) in the government finances dataset (see Figure 11 in Appendix A.2). This result holds across all considered maturities (1, 5, and 10 years). I only observe a minor difference when incorporating all spreads at the same time — the spike during the European debt crisis is slightly more pronounced. This feature reinforces the benchmark SU indicator. Appendix A.2 also reports the 12-months ahead sovereign uncertainty (see Figure 12). It can be noticed that the variability of sovereign uncertainty decreases as the prediction horizon tends to infinity. Nevertheless, the main events are still matched and several of them reinforced given that the spikes on those episodes are larger.

[9] Figure 13 in Appendix A.3 exhibits the benchmark measure of sovereign uncertainty together with two sub-indices: its price and quantity components. While the former includes uncertainty price-based series from the public finances dataset, the latter follows a similar logic regarding quantity-based indicators. The price-based component is computed by using 10 public series (out of the 31 government-related variables) and the quantity-based component by employing 21. See Appendix A.1 for data description.

- In 2003, the Spanish involvement in Iraq implied the use of a sizable amount of public resources to finance the military intervention. The estimated index also presents this situation as a period of heightened sovereign uncertainty.
- Considering the Great Recession, one can detect the presence of a significant positive spike. This event has been shown as the combination of many factors, and is therefore displayed by both sovereign and macro-financial uncertainties.
- Shortly after the start of global financial crisis in 2008, the spreads on sovereign debt of many eurozone economies (compared with Germany) began climbing and peaked during the Euro Area debt crisis. To put things into perspective, the spread on one-year Spanish bonds during the height of Euro Area debt crisis was around 350 basis points which was 14 times its mean value of 25 basis points (average over the years 1997–2010). Therefore, as Figure 1 reveals, this span constituted another great episode of uncertainty about the outlook for public finances.
- After a lengthy economic downturn from 2008 to 2013, the Spanish economy also experienced other uncertainty episodes. Concretely, we witnessed an upward trend from 2015 to 2017 in sovereign uncertainty, peaking when Spain faced serious concerns to form a government after two consecutive elections. This led to a freeze in the budget and uncertainty surrounding the public finances rose.

One might think that sovereign uncertainty is simply capturing the same uncertainty episodes compared to macro-financial or economic policy uncertainty indicators. However, I show in Figure 1 that this is not the case.[10] It can be seen that SU and MU only coincide at the spike of the Great Recession in 2008–2009. In fact, the correlation between these two measures is just 0.06 prior to the global recession. Moreover, even after 2008, particularly during the European debt crisis, the narrative also diverges: MU captures two important peaks in July 2010 and August 2012, while SU exhibits just one main episode in December 2011.[11]

Figure 1 also displays the economic policy uncertainty index (EPU) developed by Baker et al. (2016). The correlation between SU and EPU is just 0.06 for the full sample. This indicates that sovereign uncertainty clearly exhibits independent variation from economic policy uncertainty. This divergence may arise either from the fact that coverage of political events has not always resulted in increased difficulty to predict the path of the government finances, or from the fact that EPU does not explicitly control for a deterioration in expectations of the mean economic outcome when volatility increases, potentially conflating uncertainty shocks and confidence shocks.[12] Nevertheless, it is important to stress

[10] I also provide SVAR evidence in Section 3, where I show that SU and MU shocks produce notably different responses in most of the financial and macroeconomic variables.

[11] The correlation for the full sample is 0.61. However, further investigation reveals that if the period 2008–2009 is excluded (by introducing a dummy variable that takes a value of one for the period 2008–2009 and zero otherwise) the correlation again falls considerably. Consequently, one can notice that only the short span 2008–2009 is responsible for that difference.

[12] Figure 14 (Appendix A.4) also reports the economic policy uncertainty index (EPU) developed by Ghirelli et al. (2019). This paper refines the index by Baker et al. (2016) in several dimensions: they expand the headline newspaper coverage from 2 to 7 and use a much richer set of keywords to form the search expressions. The correlation between SU and their EPU is still very low at −0.04 (and not significant) for the full sample. Again, this implies that sovereign uncertainty manifests autonomous variation from economic policy uncertainty.

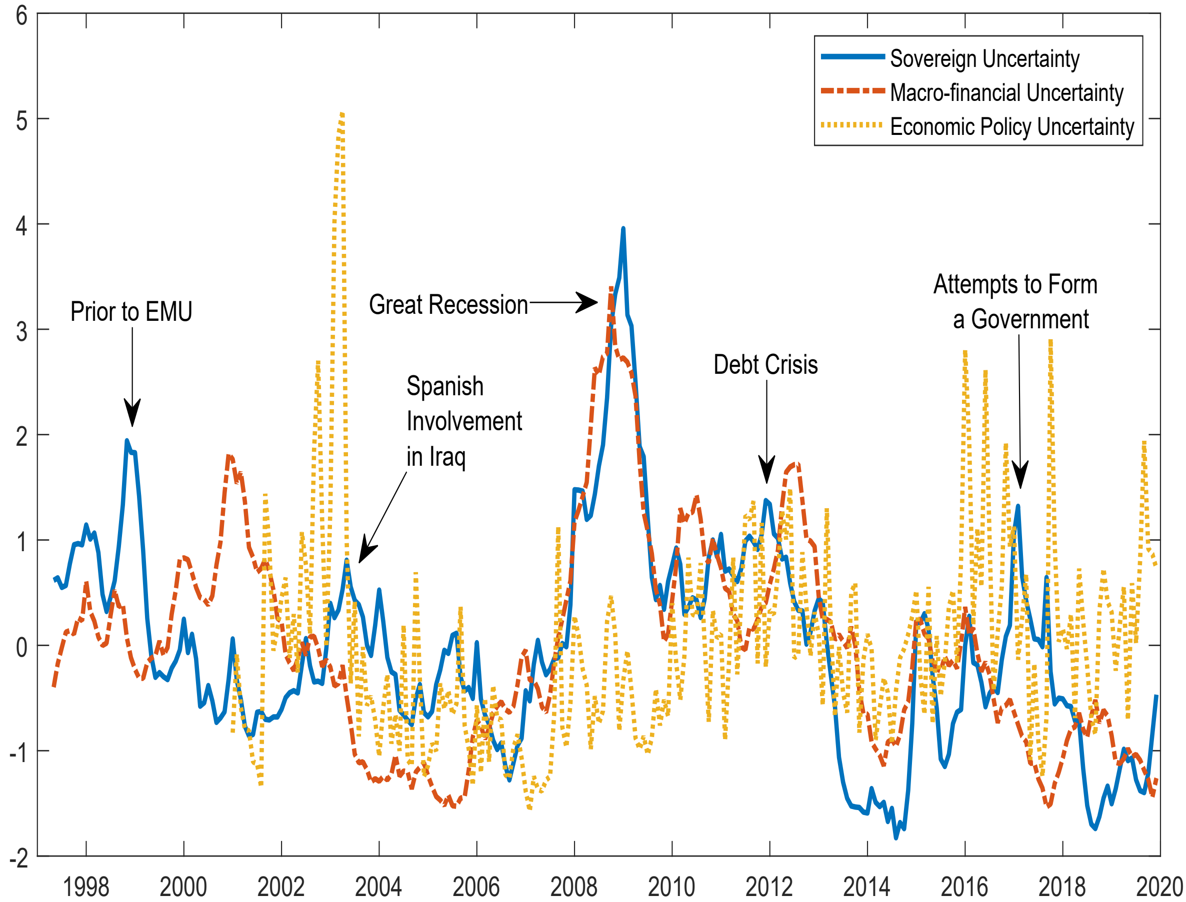

Figure 1: Sovereign Uncertainty, Macro-financial Uncertainty, and EPU

Note: The solid-blue line indicates the one-month ahead uncertainty surrounding the public finances of the Spanish economy; the dash-dot-orange line represents macro-financial uncertainty; and the dotted-yellow line exhibits the economic policy uncertainty index from Baker et al. (2016). All measures are standardized.

that both indicators feature elevated uncertainty episodes during the attempts to form a government and the Spanish intervention in Iraq.[13]

Finally, I also consider an extension that includes the COVID-19 pandemic. Figure 2 displays the SU and MU indicators up to April 2022. As can be seen, the spike in MU after the COVID-19 crisis hit the economy is substantial, but the dynamics of the SU measure are entirely different. In 2009–2013, the government deficit was between 6%-9% of GDP, and government debt fluctuated between 50% and 100%. In the post-COVID period, the public deficit was between 7%-10% of GDP, and government debt was between 100%-125%. However, as Figure 2 shows, similar trends in public finances did not give rise to similar concerns about sovereign risks. In other words, the economy did not experience significant sovereign uncertainty in the post-COVID sample relative to macro-financial uncertainty originating from disruptions in the private sector.[14]

[13]The elevated episode in EPU during the course of 2016 is mainly driving by the Catalan crisis. At this time, Spanish newspapers were reporting daily on the tensions between the central government and the Catalan analogue. This is why high spikes in the EPU index can be observed. On the contrary, the peak in SU is less pronounced. This indicates that the Catalan dispute was not transmitted to the public finance concerns as much as the EPU index reflects, nor to the macro-financial uncertainty.

[14]I thank one referee for the argument in this paragraph.

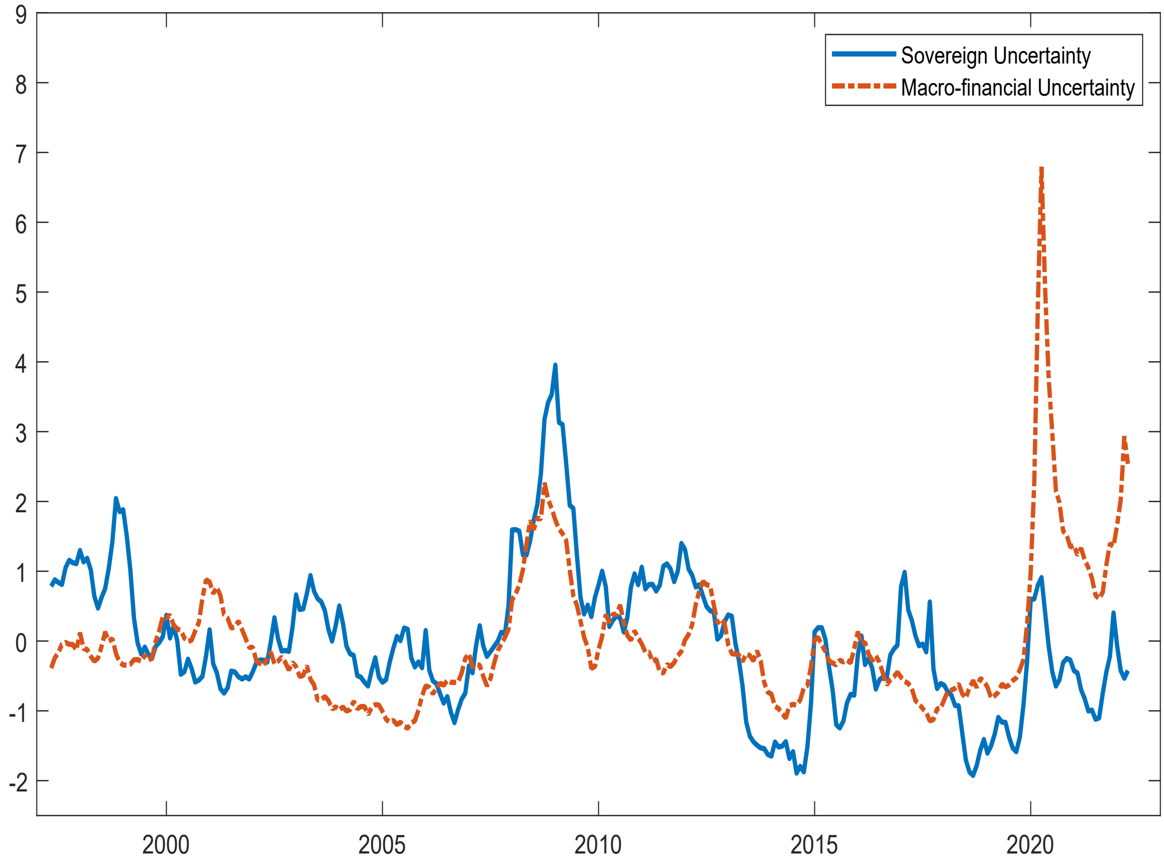

Figure 2: Sovereign Uncertainty and Macro-financial Uncertainty: Including the COVID-19 Pandemic

Note: The solid-blue line indicates the estimated sovereign uncertainty; and the dash-dot-orange line represents macro-financial uncertainty. Both measures are standardized.

3 The Macroeconomic Effects of Sovereign Uncertainty Shocks

I now explore the effects of sovereign uncertainty shocks on macroeconomic aggregates using Bayesian vector autoregression (BVAR) methods. I consider a number of alternative identification schemes. In particular, I detail potential recursive orderings and provide robustness evidence. Next, I describe reliable set-identification techniques based on a combination of sign, event-based and ratio restrictions (à la Rubio-Ramírez et al., 2010; Antolín-Díaz and Rubio-Ramírez, 2018; and Ludvigson et al., 2019).

3.1 VAR Model

The benchmark VAR specification is as follows:

$$y_t = c_0 + \sum_{k=1}^{p} \beta_k y_{t-k} + \epsilon_t, \qquad \epsilon_t \sim \mathbb{N}(0, Q), \tag{4}$$

where c_0 is a constant, y_t stands for the vector of endogenous variables and ϵ_t is a Gaussian white noise with covariance matrix Q. I employ Bayesian techniques to estimate the model. Specifically, I use a conjugate Normal-inverse Wishart prior, assuming that $vec(B) = (c_0, \beta_1 \ldots, \beta_p)$ is normally distributed and that Q has an inverse Wishart distribution.[15] The overall prior tightness is set to 0.10 and the prior on the intercept to 100. These values are standard in the literature.

I use Spanish monthly data in log-levels for all variables except those expressed in rates (see Appendix A.1.3 for data description). The sample is from May 1997 to December 2019 and the baseline model features nine lags.[16] The starting and ending dates are determined by the availability of the sovereign uncertainty measure and the presence of substantial instability in the data due to the COVID-19 pandemic (see subsection 2.2).

Recursive schemes. I first identify the shocks recursively based on a Cholesky decomposition of the variance-covariance matrix of the reduced-form residuals. The observables are (in this order) the stock market index (IBEX-35), bank loans, price level, unemployment rate, industrial production, 10-years government bond rate, public debt and sovereign uncertainty. While the extant literature has debated the exogeneity/endogeneity of uncertainty measures — Ludvigson et al. (2019) find that financial uncertainty is exogenous and macroeconomic uncertainty is not, whereas Carriero et al. (2018) claim the opposite — these studies are actually referring to other types of uncertainty with respect to the one considered here. My chosen recursive identification scheme is motivated by following the theoretical literature on sovereign risk where concerns about the sustainability of a government are often treated as endogenous drivers (see Uribe, 2006; Arellano, 2008; and Bi, 2012).[17] By ordering sovereign uncertainty last, I am able to model the possibility of other shocks in the system contemporaneously affecting the dynamics of sovereign uncertainty shocks. Nevertheless, I also test the assumption that macroeconomic uncertainty can be considered as a more exogenous component of the economy, and hence, ordered first. This recursive ordering will also permit the clear isolation of the economic mechanisms driving the propagation of sovereign uncertainty in the theoretical model. To empirically motivate this exogeneity one could rely on Longstaff et al. (2011) who investigate credit default swaps for 26 economies and find that country spreads are driven more by forces exogenous to the economy than the local forces. Further support for this position comes from Uribe and Yue (2006) who show that innovations exogenous to the local conditions can explain up to two-thirds of movement in country spreads. To be clear, these two papers do not focus on sovereign uncertainty, but investigate how different factors (internal or external) affect a specific component of the public finances. However, I consider both studies able to provide some validation for the potential exogeneity of the government's exposure to risks.[18]

[15]The Normal-inverse Wishart prior takes the following general form:

$$vec(B)|Q \sim \mathcal{N}\big(vec(\underline{B}), Q \otimes \underline{\Phi}\big)$$

and

$$Q \sim \mathcal{IW}\big(\underline{S}, \underline{\alpha}\big),$$

where $\underline{B}$, $\underline{\Phi}$, $\underline{S}$ and $\underline{\alpha}$ are functions of hyperparameters.

[16]The literature normally chooses twelve lags for monthly data. Nevertheless, results are robust to reasonable variations of the number of lags in the VAR framework.

[17]However, it is important to stress that my measure of sovereign uncertainty is aimed to capture several aspects regarding the public sustainability of a country, whereas the theoretical literature on sovereign risk mainly focuses on the probability of default which normally just depends on the level of debt or/and productivity. In other words, we are not exactly measuring the same concepts but they can be potentially linked.

[18]Exogenous elements might relate to risk appetite which may change independent of how the public finances of a particular country evolve, while endogenous would reflect developments in the government finances.

Sign, event-based and ratio restrictions. Set-identified methods have become a popular and relevant alternative to the recursive approach (see Faust, 1998; Canova and Nicolo, 2002; Uhlig, 2005; Rubio-Ramírez et al., 2010; Mumtaz and Zanetti, 2012; Antolín-Díaz and Rubio-Ramírez, 2018; and Ludvigson et al., 2019, among others). While recursive schemes are justified by economic theory in some cases, they are often inconsistent with theoretical models. The literature on set-identified restrictions proposes to employ prior information on the signs of the impact of certain shocks, combined with narrative and ratio constraints, which is normally extracted from DSGE models and/or specific economic events that have altered the dynamics of the economy. This leads to set-identified responses which are only based on imposing weak assumptions at the considered timing. Therefore, identification is less restrictive than that achieved through the traditional approach of a recursive ordering of the variables that implicitly involves the knowledge of the timing of each variable to all shocks in the system.

In order to transform the reduced-form errors, ϵ_t, into fundamental innovations, $e_t = A\epsilon_t$, it is necessary to place theoretical restrictions to recover the structural shocks. Following Rubio-Ramírez et al. (2010) for the case of sign restrictions, the procedure is to (i) obtain the estimates of the reduced-form elements B and Q; (ii) orthogonalize the innovations using a Cholesky decomposition and compute the consequent impulse responses; (iii) draw a matrix P from a *QR-decomposition* of a random standard normal matrix such that $A = \tilde{A}P$, where $\tilde{A}\tilde{A}' = Q$; and (iv) check whether the imposed signs are matched on the impulse responses (calculated with the ones obtained in the second step and P). If these are not fulfilled, redraw P until they are met. In addition, the inclusion of event-based (narrative) restrictions requires that the structural shock series is constrained on particular dates. Then, following Antolín-Díaz and Rubio-Ramírez (2018) and Ludvigson et al. (2019), the draws are just kept if the narrative is satisfied.

Previously, I have justified the differences between the SU and MU measures by showing the time series were different. Moreover, I will show that the inclusion of macro-financial uncertainty originating from disturbances in the private sector does not erase the effects of SU shocks under recursive identification schemes. But do the impulse response functions (IRFs) to shocks to both indices look different? If the two measures are really capturing different things, then, the responses should differ in the structural VAR setting. Consequently, I jointly identify a sovereign uncertainty shock and a macro-financial uncertainty shock by considering the following prior information:

- First, I implement simple and agnostic *sign restrictions*: SU shocks (MU shocks) rise SU (MU) for the first nine months.[19] The signs of the responses for other macroeconomic and financial variables remain agnostic.

[19] In practice, the half-life of sovereign uncertainty is estimated to be around 18 months (based on estimates from a univariate AR(1) model for the series) and 41 months for macro-financial uncertainty. Consequently, this can justify the election of the minimal sign restrictions during 9 months. Further investigations (available from the author upon request) reveal that when the range is diminished to six months or augmented to twelve months, the responses are consistent with the original findings. In particular, when I consider spans longer than nine months, the previous results are reinforced. In this case, it implies that the economy simply responds as if a larger temporary shock had occurred. This corroborates the findings in Bloom (2009), Fernández-Villaverde et al. (2011) and Basu and Bundick (2017), where uncertainty is also explored as a large temporary phenomenon.

- I add now the following *event-related (narrative)* and *ratio constraints*:

  (a) Motivated by the Spanish involvement in Iraq, which implied the use of a sizable amount of public resources to finance the military intervention, SU shocks are required to be positive in the aftermath of the Iraq war (March-April 2003); and negative in April 2004, where the Prime Minister of Spain pulled Spanish troops out of Iraq. In contrast, MU shocks are non-positive in March-April 2003. The choice of this narrative is driven by two crucial reasons: (*i*) following Ramey and Shapiro (1998) and Ramey (2011), the presence of this war in the SU index creates an event that is exogenous to the current state of the economy; and (*ii*) one can notice that the SU index rises during this narrative and it declines for the case of MU.[20] As it is displayed in Figure 3, this is evident for each uncertainty indicator at short and long forecasting horizons. Therefore, the aforementioned narrative imposes the minimum restrictions required to identify these two shocks.

  (b) MU shocks must be positive during the Lehman Brothers' collapse (September 2008). This episode triggered uncertainty in the U.S. economy and it propagated to the Euro Area and the rest of the world.[21]

  (c) SU and MU shocks are positive in June 2012. This is an interesting event because it represented the moment when the European Stability Mechanism (ESM) made available to Spain up to €100 billion in assistance (it is important to note that the country only needed €41.3 billion). Interestingly, this financial support was counted specifically as further sovereign debt. Thus, it could had directly affected the stability of its public finances.[22] If one follows the decomposition of uncertainty by Rossi et al. (2016), we could see a scenario where markets first experience low sovereign Knightian uncertainty but a high risk of default because turmoil is market-driven. Then, when the ESM financial package arrives, the risk of fragmentation in the Euro Area disappears but sovereign Knightian uncertainty increases due to the political process of determining the terms and conditions of the assistance.

  (d) Finally, SU (MU) shocks produce, upon impact, a response of the SU-MU ratio above (below) one. The rationale is that events inducing sovereign uncertainty may also increase macro-financial uncertainty, but have larger effects on sovereign uncertainty itself on impact. As time goes by, the SU-MU ratio is endogenously determined and, consequently, it is not constrained.[23]

[20]Macro-financial uncertainty is normally linked to periods of economic slowdown (see e.g. Jurado et al., 2015). During the Iraq war episode, the Spanish economy was not in recession according to the historical archive of the Spanish Business Cycle Dating Committee.

[21]Nonetheless, around this event, there was already a substantial amount of uncertainty in the Spanish economy due to its housing market crash and the upcoming restructuring of its banking sector.

[22]While this constraint in June 2012 could be justified in the case of sovereign uncertainty, I cannot rule out the possibility that this event also impacted overall economic uncertainty. This is the reason why I assume that both SU and MU shocks are non-negative during this month.

[23]Ratio restrictions, in general, are also considered in Furlanetto et al. (2019) and Caggiano et al. (2020).

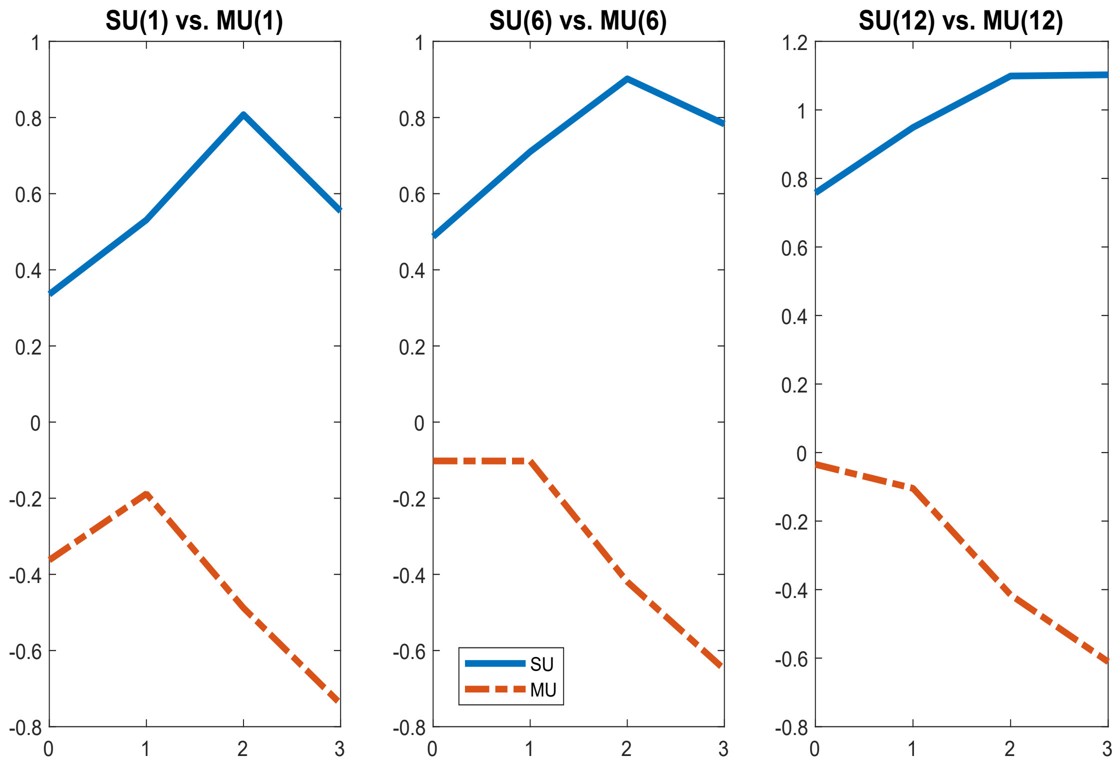

Figure 3: Narrative around the Iraq War: $t = 0$ is March 2003

Note: The figure exhibits the estimated 1-month, 6-months and 12-months ahead uncertainties for both SU (solid-blue lines) and MU (dash-dot-orange) indices. All measures are standardized.

3.2 VAR Results

In this section, I first examine the findings employing the recursive identification and then continue with those obtained through sign, event-based and ratio restrictions. Exhaustive robustness checks for both identification strategies are also explored.

3.2.1 Findings under Recursive Identification

Figure 4 plots the impulse responses to a one standard deviation shock to sovereign uncertainty in the recursive identification. One can observe that all the variables decline except unemployment rate and government debt. The impact on the long-term rate is inconclusive. It seems to fall in the short-run, but it rises over time.[24] In detail: industrial production begins to decline and does not hit the bottom until 15 months later, when it reaches its lowest value of nearly -0.6%. The stock market index and overall price level follow similar paths before approaching their lowest points of around -0.75% and -0.1%, respectively. Bank lending by roughly -1.4%, whereas unemployment rate and government debt rise, respectively, by around 0.2% and 0.7% at their maximum levels. These results potentially suggest that an increase in sovereign uncertainty operates as a negative demand shock. In the theoretical section, I will examine how a sovereign uncertainty shock can be transmitted to the real economy. Now, I compare my empirical

[24] I have checked that the benchmark results do not change when substituting the 10-years government bond rate for its spread with respect to Germany. However, the latter does not react on impact and it gradually increases over time (see Figure 15 in Appendix A.5.1).

findings with previous studies on uncertainty shocks. However, it is important to note that these concern the role of different types of uncertainty and none specifically focus on sovereign uncertainty shocks.

The rise in unemployment is in line with the theoretical predictions of Leduc and Liu (2016) following a TFP uncertainty shock. They show that search frictions give rise to a real option-value effect that is contractionary. This is so given that a job match in their model represents a long-term employment contract that is irreversible. This follows the same logic as in the model of irreversible investment outlined in Bernanke (1983), where agents postpone their investment decisions until business conditions become clearer. The decline in prices also supports the findings in Leduc and Liu (2016), as well as in Christiano et al. (2014) and Basu and Bundick (2017). This contrasts with the theoretical results of Born and Pfeifer (2014) and Fernández-Villaverde et al. (2015), who find that policy uncertainty shocks imply an upward pricing bias channel where firms end up setting prices higher than they would otherwise do. Nonetheless, Fernández-Villaverde et al. (2015) also show that when the model allows the monetary authority to react to policy

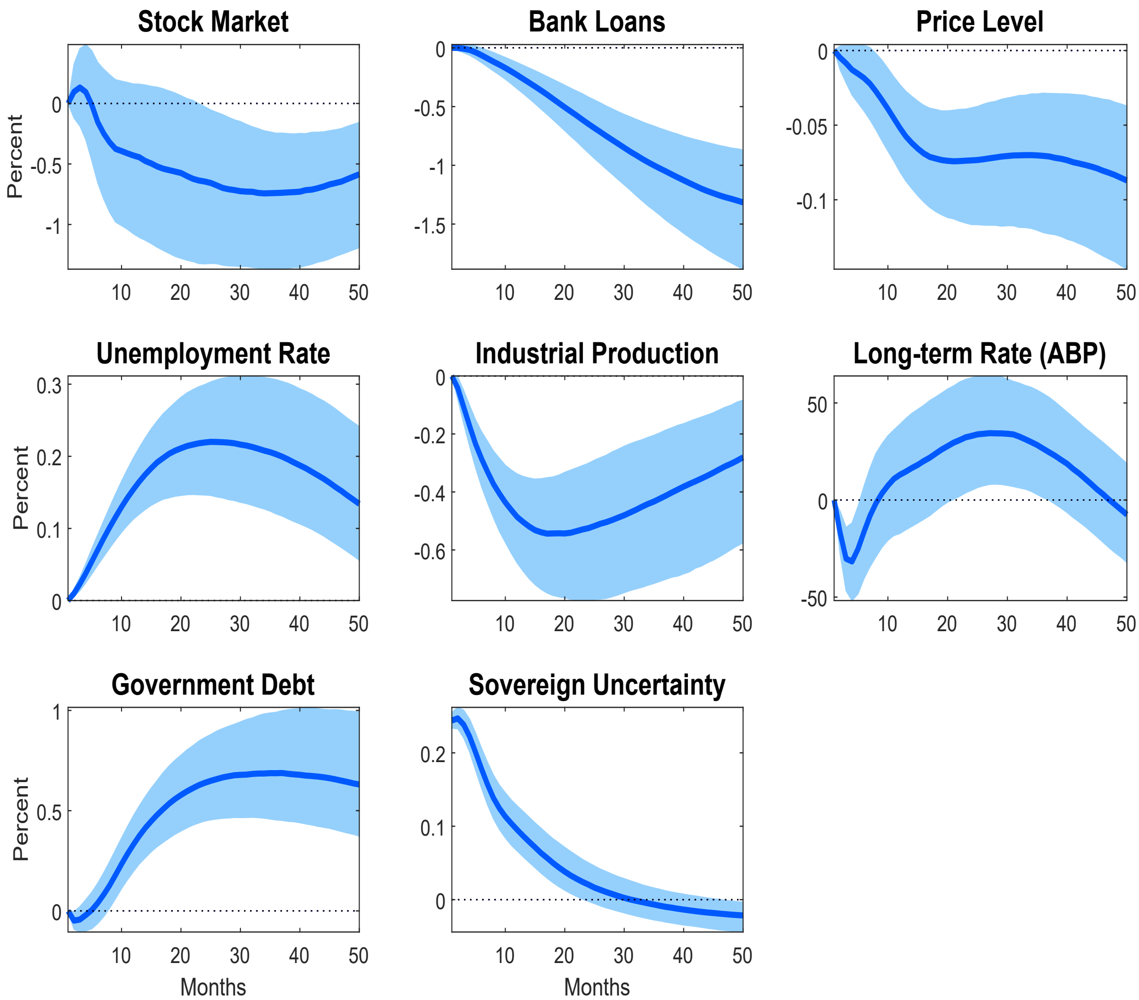

Figure 4: IRFs to One Standard Deviation Shock to Sovereign Uncertainty: Baseline Recursive Ordering

Note: Each entry shows the median and the 68% credible bands. All responses are in monthly percent deviations from trend, except for the unemployment rate and the long-term rate, which are expressed in monthly percentage points and annualized basis points (ABP), respectively.

uncertainty, the theory matches the observed evidence. Concerning the banking sector, the drop in lending is consistent with the work of Bonciani and van Roye (2016). They argue that banking frictions in credit supply amplify the effects of a volatility shock to households' preferences on economic activity. The decline in industrial production is recognized in Jurado et al. (2015) for the U.S. economy, and in Meinen and Röehe (2017) for Spain, both employing aggregate measures of macroeconomic uncertainty.

Finally, the dynamics of government debt deserve further discussion. Its muted response on impact and its increase over time reflect the notion that my second-moment shock is independent of a first-moment shock, such as an unexpected increase in the level of public debt. As previously asserted, my approach does control for a worsening in expectations of the mean economic outcome when volatility rises. Within this framework, a shock to sovereign uncertainty indicates that the level of public debt begins to experience larger fluctuations in the future. Theoretically, these dynamics could result in either a positive or negative impact on the level of government debt. However, in my sample, it appears that SU shocks are associated with future increases, on average, in public debt. Put differently, the prevailing uncertainty about the outlook for government finances materializes in elevated levels of public debt over the medium term, but not upon impact.

Robustness of recursive identification. As I have discussed previously, sovereign uncertainty could be affected by more international factors as compared to domestic factors. In this regard, Figure 22 in Appendix A.5.1 displays the robustness of the baseline findings when SU is ordered first.[25] Qualitatively the results are similar but they are now larger in magnitude and the response of the stock market index is already negative on impact. Figure 22 shows further checks with respect to the baseline specification, principally, regarding the presence of potential omitted variables.[26] The inclusion of both consumer and industrial confidence is made to disentangle the effects of confidence shocks from uncertainty shocks. As it is normally argued in the literature, uncertainty could arise from information-noisy news. Thus, there may exist a link between them when agents receive bad news about the future and the economy is stuck in an elevated uncertainty state (see, for instance, Piffer and Podstawski, 2018). To this end, I test that SU shocks do not resemble negative confidence shocks by individually including consumer and industrial confidence first in the VAR model. Additionally, I consider fundamental to further scrutinize the effects of sovereign uncertainty by taking into account the presence of macro-financial uncertainty arising from disruptions in the private sector. Despite I have previously shown that my sovereign uncertainty index is weakly correlated with macro-financial uncertainty prior to the great recession and that they only share a common spike in this period, the lack of inclusion of this type of uncertainty could produce upper-biased estimates in the aftermath of a sovereign uncertainty shock. I then include the measure of macro-financial uncertainty last in the baseline specification following Ludvigson et al. (2019). The vector featuring MU predicts somewhat milder responses with respect to the baseline case. Nevertheless, this scenario still confirms the sizable and long-lived effects of SU shocks. Figure 22 also reports the results when varying the lag order.

Next, what is the potential relevance of the data-rich approach? As noted earlier, a crucial difference with respect to Born and Pfeifer (2014) or Fernández-Villaverde et al. (2015) is

[25]See also Appendix A.5.1 for the complete set of median IRFs with their respective credible bands.

[26]The inclusion of more variables in the system can help to disentangle the "correct" decisions of the different agents in the economy. In other words, the econometrician has access to a larger set of information in the extended model and thus the dynamics can vary with respect to the baseline case.

that my government-related uncertainty measure is based on a high-information content approach. The exclusion of this feature could potentially be the reason behind the minor role played by their policy uncertainty shocks. Hence, I could construct an alternative measure of sovereign uncertainty by just employing data from a single time series in the public finance dataset and check how the results would change. For example, one can analyze the time-varying volatility of the unexpected component of public debt.

First, in Appendix A.5.3, Figure 28 displays the indicators of uncertainty for both short-term and long-term measures of public debt, alongside the SU index. It is worth noting that the individual uncertainty indicators fail to capture important spikes in various historical events. The timing of these episodes also varies, as exemplified by the euro area debt crisis. Second, Figure 29 and Figure 30 show that the impact on the real economy is clearly reduced when these individual measures of uncertainty are imposed. It can be observed that bank lending, unemployment rate and industrial production are not significantly affected, especially in the case of long-term debt uncertainty. Furthermore, the implications for the price level vary depending on the specific debt measure employed.

In the FAVAR model, I consider various factors that impact a broader spectrum of public finances instead of focusing on a single element. This approach aligns with the discussion in Anzuini et al. (2020), where they look at the overall cyclically-adjusted primary deficit and not just to some of its components. Their broader variable stands out as the most frequently employed indicator of the government's fiscal stance. In my case, I incorporate government instruments with different maturities and owners. This extension is particularly relevant for debt sustainability analysis (DSA). DSA serves as a valuable tool for fiscal monitoring and for making decisions regarding the allocation of financial assistance by international organizations (see Alcidi and Gros, 2018 and Burriel et al., 2023). This literature has shown that allowing for a rich setup to take into account different funding sources in terms of maturities and costs is crucial for DSA. Consequently, the previous findings confirm the importance of a rich-information strategy when measuring the effects of sovereign uncertainty shocks.

Finally, does the transmission of sovereign uncertainty rely exclusively on periods of economic slowdown? It could be also assumed that the negative and persistent effects of sovereign uncertainty shocks are only driven by the Great Recession or the European debt crisis. To assess this question, I consider a threshold VAR model to account for the presence of potential non-linearities. The importance of non-linearities when analyzing the effects of uncertainty shocks has been recently stressed by the literature (see Auerbach and Gorodnichenko, 2012; Caggiano et al., 2014; Caggiano et al., 2017; Liu et al., 2019 and Alessandri and Mumtaz, 2019). Appendix A.6 details the estimation strategy and confirms that the effects of sovereign uncertainty shocks during recessions are indeed stronger, especially in the short-run. However, contrary to the findings of other studies in the U.S. using measures of macroeconomic or economic policy uncertainty, the effects in booms found here are sizable (see Figure 41). This implies that economic downturns are not the sole drivers of the detrimental consequences of sovereign uncertainty shocks.

3.2.2 Findings under Identification with Sign, Event-based and Ratio Restrictions

I turn now to discuss the empirical findings when a combination of sign, event-based and ratio restrictions is employed. Figure 5 reports the baseline effects of a one standard

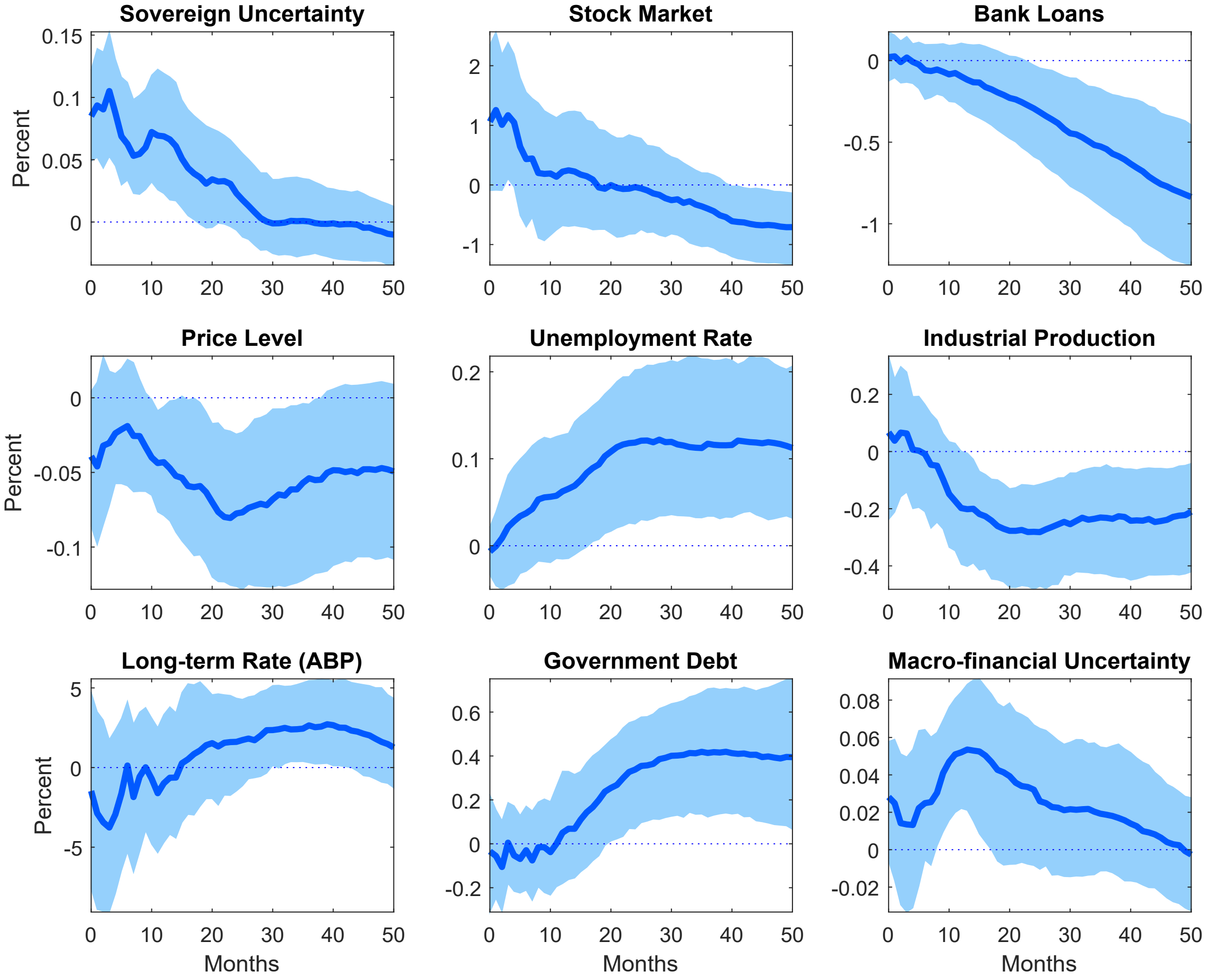

Figure 5: IRFs to One Standard Deviation Shock to Sovereign Uncertainty: Baseline Identification with Sign, Event-based and Ratio Restrictions

Note: Each entry shows the median and the 68% credible bands. All responses are in monthly percent deviations from trend, except for the unemployment rate and the long-term rate, which are expressed in monthly percentage points and annualized basis points (ABP), respectively.

deviation shock to SU.[27] I found, in general, similar results as in the case where the sovereign uncertainty shocks are identified with a Cholesky decomposition.[28] In particular, the responses of bank loans, unemployment rate, industrial production, price level and government debt are qualitatively the same. However, some differences emerge when I consider the stock market. Without imposing any prior beliefs on the response of this variable, it is not clear whether it significantly moves as a consequence of a sovereign

[27]Figure 31 in Appendix A.5.4 reports forecast error variance decomposition for selected variables (the ones that produce statistically significant IRFs) attributable to SU shocks. I find that this source of perturbation plays an important role in business cycle fluctuations. I have also performed a historical decomposition analysis to see how important any of the uncertainty indicators are in historical period (Appendix A.5.5).

[28]In Appendix A.5.6, I have reported the constructed SU (MU) series and the estimated SU (MU) shocks under each identification method. In general, one can notice that the recursive scheme imposes stronger restrictions among the variables, and consequently, it produces larger spikes in the shock series. On the contrary, the less restrictive identification inherent in the narrative approach yields less volatile series. It is worth mentioning that the estimated MU shocks are larger in September and October 2008 when considering the variant of the narrative identification.

uncertainty shock or not. This pattern is also present in the reaction of the long-term rate, but in this case, the mass of the distribution of the response is inclined toward the positive plane as time goes by (as in the recursive identification).

Regarding MU shocks, it can be seen from Figure 5 and Figure 6 that the results support the previous evidence, i.e., the effects of SU and MU shocks respectively differ. While the former perturb the economy in the medium-run, the latter display short-lived responses in real activity. Specifically, industrial production, unemployment rate and government debt react persistently more after a SU shock. Bank lending seems to decline shortly after impact in the aftermath of a MU shock, whereas it strongly decreases after 24 months following a SU shock. It is worth noting that the brief impact of MU shocks is only significant for industrial production. Nevertheless, a variant of the baseline narrative

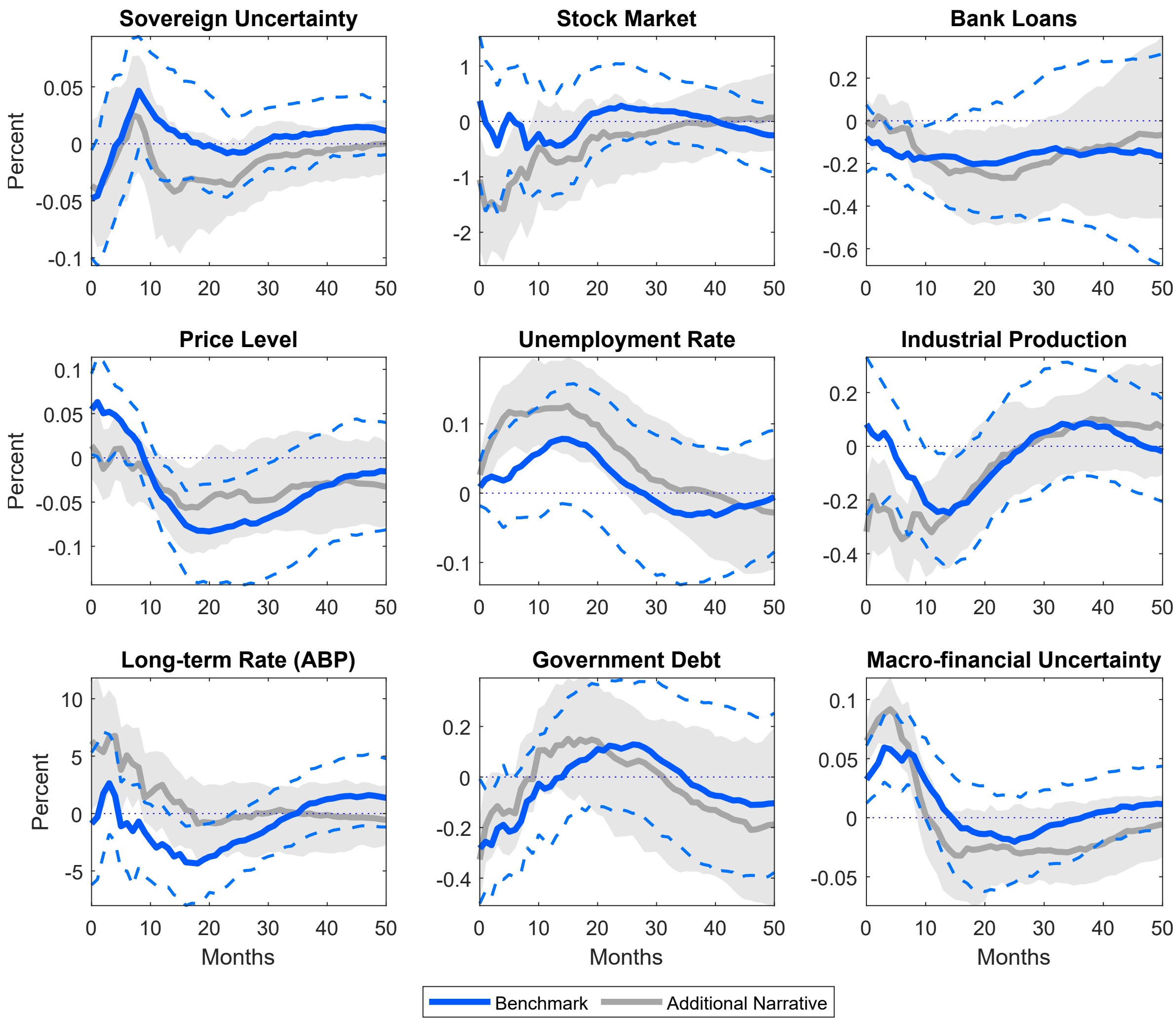

Figure 6: IRFs to One Standard Deviation Shock to Macro-financial Uncertainty: Baseline Identification and the Additional Constraint

Note: Each entry shows the median and the 68% credible bands. All responses are in monthly percent deviations from trend, except for the unemployment rate and the long-term rate, which are expressed in monthly percentage points and annualized basis points (ABP), respectively. The blue line displays the results under the baseline identification with sign, event-based and ratio restrictions. The gray line exhibits the responses under the additional narrative: The MU shock is the most important contributor to the unexpected changes observed in the MU index following the Lehman Brothers' Collapse (September-October 2008).

identification strengthens the results of MU shocks, rendering the previous responses significant (gray lines in Figure 6). In particular, I assume that a MU shock is the most important contributor to the unexpected changes observed in the MU index following the Lehman Brothers' Collapse (September-October 2008).[29] The additional restriction essentially constrains the historical decomposition of the MU shock around this specific episode, and confirms again the diverse nature of both types of uncertainty shocks.[30]

Robustness of identification through sign, event-based and ratio restrictions. How decisive are the previous restrictions in order to identify a sovereign uncertainty shock? I propose the following set of robustness checks under this type of identification: (*i*) considering other prior beliefs about the narrative of SU shocks; and (*ii*) accounting for potential omitted variables in the baseline vector of agents' information.

One could expect that the initial restrictions imposed are crucial or necessary for the identification of the structural shocks of interest. I study two variants of the benchmark event-based identification strategy. Firstly, I augment the set of narrative information with the bailout of the Spanish "Cajas", which occasionally involved a government guarantee and could be perceived as a risk to public finances (thus, it can be treated as a positive SU shock). In particular, I consider the bailout of Bankia in May 2012. Secondly, I analyze an event in July 2012, when former President Mariano Rajoy announced austerity measures, including cuts in spending and tax increases. This reduced the deficit significantly and improved forecasts of future deficits. Consequently, this event could be considered as a negative shock to SU.[31] Figure 24 and Figure 25 in Appendix A.5.2 prove that it is possible to obtain results analogous to the ones reported in Figure 5 by just imposing a different combination of narrative restrictions.[32]

As in the recursive identification scheme, I consider now the presence of potential omitted variables in the model. That is, I control for both confidence about the future and global economic policy uncertainty (GEPU).[33] As previously noted for the former case, this inclusion is important given that there exist several studies who clearly show that news and uncertainty shocks are interconnected (see e.g. Forni et al. 2017; Cascaldi-García and Galvão 2018; and Lagerborg et al. 2019). Next, it is also relevant to confirm that shocks to SU still survive in the presence of global uncertainty (see e.g. Berger et al. 2016 and Cesa-Bianchi et al. 2019). Figure 26 and Figure 27 in Appendix A.5.2 certify the stability of the baseline results.

Altogether, regardless of the identification strategy, sovereign uncertainty shocks have significant and persistent negative effects on bank lending. The effects of these shocks

[29]The draws that satisfy this additional narrative are fewer than in the benchmark case. Consequently, this accounts for the less regular patterns observed in the IRFs.

[30]Figure 23 in Appendix A.5.2 shows that the credible set is also smaller than in the baseline scenario for SU shocks.

[31]I thank one referee for the narrative in this paragraph.

[32]In July 2012, former European Central Bank President Mario Draghi pronounced his famous "whatever it takes". This event is generally considered as a turning point because it reverted the negative situation around the European public finances. In other words, it can be treated as a positive outcome. Then, one may assign a positive sign to the SU shock occurring in July 2012. This extra restriction does not alter the baseline IRFs (results are available upon request).

[33]The GEPU index is a GDP-weighted average of national EPU indices for 21 countries and it is obtained from `www.PolicyUncertainty.com`.

are translated to the larger economy leading to a prolonged and significant downturn in industrial production, with evidence of deflationary pressures. At the same time, they are accompanied by significant rises in unemployment rate and government debt. Finally, to show that these findings are indeed stable, I have performed a battery of robustness checks. For the rest of macroeconomic aggregates — stock market index and long-term interest rate — the results are more ambiguous.

4 Theoretical Framework

In this section, I introduce an approximation for sovereign uncertainty in a DSGE model with recursive preferences and financial intermediaries to rationalize my empirical results. In particular, the objective is to investigate whether the model can effectively match the empirical evidence of an uncertainty shock originating from changes in the public financial sector, and if so, which important theoretical assumptions are necessary to achieve it.

4.1 A New Keynesian DSGE Model with Sovereign Uncertainty, EZ Preferences, and Banking Sector

The starting point is a canonical New Keynesian DSGE model augmented with financial intermediation as in Gertler and Karadi (2013) and Epstein-Zin (EZ) preferences. In the extended framework, banks hold government bonds. I explicitly model the real interest rate on these bonds as the sum of return on a perpetuity and an exogenous additive term which is subject to a stochastic volatility shock. I will refer to the latter as an approximation for sovereign uncertainty. I postpone a full justification for this choice to the end of section. In addition, the model is solved by a third-order perturbation method (Fernández-Villaverde et al., 2011 and Basu and Bundick, 2017) and estimated by matching model's moments with corresponding moments from the data.

The whole economy is populated by households, banks, intermediate producers, retail goods firms, capital goods producers and a monetary authority. The central bank's actions can be directly affected by sovereign uncertainty shocks in an augmented Taylor rule. The following sections detail the agents' decision problems.

4.1.1 Households

There is a continuum of identical households of unity mass. Each household is composed by a fraction m of bankers and a fraction $1-m$ of workers. Each banker manages a financial intermediary and returns earnings to the household. Workers supply labor and similarly transfer their wages back to the household. Additionally, there is perfect consumption insurance within the family.

The problem of the household is formalised as follows:

$$V_t = max\left[(1-\beta)(C_t^{\nu}(1-H_t)^{1-\nu})^{\frac{1-\sigma}{\theta_V}} + \beta(\mathbb{E}_t V_{t+1}^{1-\sigma})^{\frac{1}{\theta_V}}\right]^{\frac{\theta_V}{1-\sigma}}, \tag{5}$$

where C_t denotes consumption, H_t is labor supply, β is the discount factor, ν controls labor supply, σ governs risk aversion, and $\theta_V = (1-\sigma)/(1-(1/\psi))$. The latter is an index of the deviation with respect to the CRRA utility function where ψ regulates household's elasticity of intertemporal substitution (EIS). When $\theta_V = 1$, the recursive preferences collapse to the CRRA case and the inverse of the EIS and risk aversion coincide.[34]

The maximisation problem is subject the household's budget constraint:

$$D_t + C_t = R_{t-1}D_{t-1} + W_tH_t + T_t + \Pi_t, \tag{6}$$

where D_t refers to deposits in intermediaries that the household does not own, receiving the real interest rate R_t. Moreover, it supplies labor for the real wage W_t and pays lump-sum taxes T_t. Through its ownership of goods and capital producing firms, the household receives the profit Π_t.

Denoting by ϱ_t the Lagrange multiplier associated with the resource constraint, the optimality conditions for the household's maximization problem with respect to deposits, labor and consumption are:

$$1 = \mathbb{E}_t\Lambda_{t,t+1}R_{t+1}, \tag{7}$$

$$W_t = \frac{(1-\nu)}{\nu}\frac{C_t}{(1-H_t)}, \tag{8}$$

$$\varrho_t = \frac{\nu(C_t^{\nu}(1-H_t)^{1-\nu})^{\frac{1-\sigma}{\theta_V}}}{C_t}(1-\beta)U_t^{1-\frac{1-\sigma}{\theta_V}}, \tag{9}$$

where

$$\Lambda_{t,t+1} = \beta\left(\frac{C_{t+1}^{\nu}(1-H_{t+1})^{1-\nu}}{C_t^{\nu}(1-H_t)^{1-\nu}}\right)^{\frac{1-\sigma}{\theta_V}}\left(\frac{C_t}{C_{t+1}}\right)\left(\frac{V_{t+1}^{1-\sigma}}{\mathbb{E}_tV_{t+1}^{1-\sigma}}\right)^{1-\frac{1}{\theta_V}}. \tag{10}$$

The last equation represents the stochastic discount factor $\Lambda_{t,t+1}$ (between periods t and $t+1$) implied by the Epstein-Zin preferences. From now on, one period corresponds to one-quarter.

4.1.2 Intermediate Goods Producers

The intermediate goods firms produce their output following a Cobb-Douglas production function using capital, K_t, and labour, H_t:

$$Y_t = A_tK_t^{\alpha}H_t^{1-\alpha}, \quad 0 < \alpha < 1, \tag{11}$$

where α is output elasticity with respect to capital, $1-\alpha$ is labour elasticity, and A_t is total factor productivity (TFP).

In order to finance the capital acquisition, the firm must obtain funds from a financial intermediary. It therefore issues securities, S_t, equal to number of units of capital it acquires, K_{t+1}, pricing each claim at the unit price of capital, Q_t. Letting P_{mt} be the relative price of intermediate goods at time t and assuming the firm makes zero profits every period, the rate of return to the bank on the loan, R_{t+1}^k, is given by:

[34] I employ EZ preferences following Caldara et al. (2012) and Basu and Bundick (2017). The latter study demonstrates that models with flexible prices cannot reproduce the negative co-movement between output, consumption and investment. However, macroeconomic uncertainty shocks can generate this comovement through sticky prices. Given the importance of this result for the uncertainty literature, I opt for using the same type of preferences to clearly isolate the specific impact of price rigidities. As I will explain later, sovereign uncertainty shocks are much less influenced by sticky prices than macroeconomic uncertainty shocks, even after controlling for households' preferences. Appendix B.3 further discusses the role of EZ preferences.

$$R^k_{t+1} = \frac{\xi_{t+1}[P_{m,t}\frac{\alpha Y_{t+1}}{K_{t+1}} + (1-\delta)Q_{t+1}]}{Q_t}, \tag{12}$$

where δ is the gross depreciation rate and ξ_t is a capital quality shock whose law of motion is given as:

$$\xi_t = \rho_\xi \xi_{t-1} + u_{\xi,t}, \text{ with } u_{\xi,t} \sim \mathbb{N}\big(0, \sigma^2_\xi\big). \tag{13}$$

The capital stock for $t+1$ evolves according to:

$$K_{t+1} = \xi_{t+1}[I_t + (1-\delta)K_t], \tag{14}$$

and the firms' demand for labour is equal to the marginal productivity of labour:

$$W_t = P_{m,t}(1-\alpha)\frac{Y_t}{H_t}. \tag{15}$$

4.1.3 Capital Goods Producers

Capital producers use final output as an input to make new capital. They sell this capital to investing firms at the price Q_t. Capital goods producers choose I_t that maximizes the expected lifetime profits given by:

$$\max \ \mathbb{E}_t \sum_{\tau=t}^{\infty} \Lambda_{t,\tau} \left\{ Q_\tau I_\tau - \left[1 + f\left(\frac{I_\tau}{I_{\tau-1}}\right)\right] I_\tau \right\}, \tag{16}$$

where investment adjustment costs have the following functional form:

$$f\left(\frac{I_t}{I_{t-1}}\right) = \frac{\vartheta}{2}\left(\frac{I_t}{I_{t-1}} - 1\right)^2. \tag{17}$$

The resulting first-order condition indicates that the price of capital goods equals the marginal cost of investment goods production:

$$Q_t = 1 + f\left(\frac{I_t}{I_{t-1}}\right) + \frac{I_t}{I_{t-1}} f'\left(\frac{I_t}{I_{t-1}}\right) - E_t\Lambda_{t,t+1}\left(\frac{I_{t+1}}{I_t}\right)^2 f'\left(\frac{I_{t+1}}{I_t}\right). \tag{18}$$

Profits arising outside the steady state are rebated to households in lump-sum fashion.

4.1.4 Retail Firms

There exists a unit continuum of monopolistic firms who repackage the intermediate output. Final output, Y_t, is a CES aggregator of differentiated retailers output, $Y_t(i)$, given by:

$$Y_t = \left(\int_0^1 Y_t(i)^{\frac{\epsilon-1}{\epsilon}} di\right)^{\frac{\epsilon}{\epsilon-1}}, \tag{19}$$

where ϵ is the elasticity of substitution between different retail goods. The demand curve for each good is thus given by:

$$Y_t(i) = \left(\frac{P_t(i)}{P_t}\right)^{-\epsilon} Y_t. \tag{20}$$

Monopolistic retailers convert one-to-one the intermediate output into the final good. The marginal cost is therefore the relative intermediate output price $P_{m,t}$. I introduce nominal rigidities following Rotemberg (1982). In particular, the retailer i maximizes:

$$\mathbb{E}_t \sum_{j=0}^{\infty} \Lambda_{t+j} \left(\frac{P_{t+j}(i) - P_{m,t}}{P_{t+j}} Y_{t+j}(i) - \frac{\phi_P}{2} \left(\frac{P_{t+j}(i)}{P_{t+j-1}(i)} - \pi \right)^2 Y_{t+j} \right), \tag{21}$$

subject to the demand function in Equation (20).

4.1.5 Banks

The modeling of financial intermediaries draws from Gertler and Karadi (2013). Nonetheless, I describe here their main choices and interactions with the real economy for the sake of completeness. Accordingly, banks finance their operation by obtaining deposits from households, D_t, and through their own net worth, N_t. Moreover, they lend to non-financial firms and invest in government bonds, B_t. Their balance sheet is then given by:

$$Q_t S_t + Q_t^B B_t = N_t + D_t, \tag{22}$$

where S_t is the quantity of financial claims on non-financial firms that the intermediary holds, and the relative prices of private claims and government bonds are Q_t and Q_t^B, respectively.

The law of motion for the net worth of banks is given by the combination of the balance sheet and the flow of funds:

$$N_t = (R_t^k - R_t) Q_{t-1} S_{t-1} + (R_t^B - R_t) Q_{t-1}^B B_{t-1} + R_t N_{t-1}. \tag{23}$$

The bankers objective is to maximize the present value of their terminal wealth discounted with the household's intertemporal marginal rate of substitution, $\Lambda_{t,t+i}$. Each banker transfers the remaining net worth to its household as a lump-sum payment and exits the market with probability $1-\theta$. Formally, the maximization problem can be expressed as:

$$V_t = \mathbb{E}_t \sum_{i=1}^{\infty} \Lambda_{t,t+i} (1-\theta) \theta^{i-1} N_{t+i}. \tag{24}$$

As in Gertler and Karadi (2013), in order to motivate a limit on bank's ability to expand its assets indefinitely by accepting more deposits, it is assumed that a bank is able to divert a proportion λ of funds back to its own household at the end of every period. Therefore, the incentive to default reduces the amount that depositors are willing to lend to the banks. In this framework, it is also assumed that it is easier for a bank to divert a higher proportion of private loans than diverting funds from government bonds. Concretely, λ is the diverted fraction of private assets and $\lambda\Delta$ of government bonds with $0 \leq \Delta < 1$. This difference can be easily motivated by the lower monitoring ability of deposit holders. Accordingly, the incentive constraint is given as:

$$V_t \geq \lambda (Q_t S_t + \Delta Q_t^B B_t). \tag{25}$$

Solving the banker's problem by maximizing Equation (24) subject to Equation (22), Equation (23), and Equation (25), yields the following inequality restriction holding with equality:

$$Q_t S_t + \Delta Q_t^B B_t \leq \phi_t N_t, \tag{26}$$

where time-varying leverage is written as:

$$\phi_t = \frac{\mathbb{E}_t \tilde{\Lambda}_{t,t+1} R_{t+1}}{\lambda - \mathbb{E}_t \tilde{\Lambda}_{t,t+1}(R_{t+1}^k - R_{t+1})}, \tag{27}$$

and with $\tilde{\Lambda}_{t,t+1}$ being the bank's stochastic discount factor augmented by the multiplier Ω_{t+1}:

$$\tilde{\Lambda}_{t,t+1} \equiv \Lambda_{t,t+1} \cdot \Omega_{t+1}. \tag{28}$$

The weight Ω_{t+1} reflects the shadow value of a unit of net worth to the bank at $t+1$ and is given by:

$$\Omega_{t+1} = 1 - \theta + \theta \mathbb{E}_t \tilde{\Lambda}_{t,t+1}[(R_{t+1}^k - R_{t+1})\phi_t + R_{t+1}]. \tag{29}$$

Moreover, expected excess returns on banks assets must satisfy the following arbitrage condition:

$$\mathbb{E}_t \tilde{\Lambda}_{t,t+1}(R_{t+1}^B - R_{t+1}) = \Delta \mathbb{E}_t \tilde{\Lambda}_{t,t+1}(R_{t+1}^k - R_{t+1}). \tag{30}$$

Total net worth evolves as the sum of retained earnings by the surviving fraction θ of the bankers and the transfers that new bankers receive:

$$N_t = \theta \left[\frac{(R_t^k - R_t) Q_{t-1} S_{t-1}}{N_{t-1}} + \frac{(R_t^B - R_t) Q_{t-1}^B B_{t-1}}{N_{t-1}} + R_t \right] N_{t-1} + TR_t, \tag{31}$$

where

$$TR_t = \omega(Q_{t-1} S_{t-1} + Q_{t-1}^B B_{t-1}). \tag{32}$$

4.1.6 Securities Holdings by Households

Following Gertler and Karadi (2013), I now permit direct household participation in asset markets and assume that a household pays a cost equal to the percentage $\frac{1}{2}\kappa(S_t^h - \bar{S}^h)^2/S_t^h$ of the value of its portfolio for $S_t^h \geq \bar{S}^h$. Similarly, there is a holding cost for government bonds which equals the percentage $\frac{1}{2}\kappa(B_t^h - \bar{B}^h)^2/B_t^h$ of the total value of government bonds for $B_t^h \geq \bar{B}^h$. This assumption captures in a parsimonious way limited participation in financial markets by households.

After allowing households to directly hold private securities and government bonds, the initial budget constraint becomes:

$$\begin{aligned} D_t + C_t + Q_t \left[S_t^h + \frac{1}{2}\kappa(S_t^h - \bar{S}^h)^2/S_t^h \right] + Q_t^B \left[B_t^h + \frac{1}{2}\kappa(B_t^h - \bar{B}^h)^2/B_t^h \right] \\ = R_{t-1} D_{t-1} + R_t^k S_{t-1}^h + R_t^B B_{t-1}^h + W_t H_t + T_t + \Pi_t. \end{aligned} \tag{33}$$

Resolving the household's optimization problem leads to the same firs-order conditions for deposits, labor supply and consumption as before. The optimality conditions for private securities and government bonds are given by:

$$S_t^h = \bar{S}^h + \frac{\mathbb{E}_t \Lambda_{t,t+1}(R_{t+1}^k - R_{t+1})}{\kappa}, \tag{34}$$

$$B_t^h = \bar{B}^h + \frac{\mathbb{E}_t \Lambda_{t,t+1}(R_{t+1}^B - R_{t+1})}{\kappa}. \tag{35}$$

It can be noted that when marginal costs go to zero, excess returns disappear and households are able to engage in frictionless arbitrage of security returns. On the contrary, when marginal costs grow to infinity, households demand their respective frictionless values.

In this extended case, the equilibrium conditions in the markets for loans and government bonds read now as:

$$S_t = S_t^b + S_t^h, \tag{36}$$

$$B_t = B_t^b + B_t^h, \tag{37}$$

where S_t^h and B_t^h are, respectively, household holdings of private securities and government bonds, while S_t^b and B_t^b are the amounts held by banks.

4.1.7 An Approximation for Sovereign Uncertainty

Every government bond is a perpetuity and pays one euro per period indefinitely. In order to introduce sovereign uncertainty in the model, I assume that the real interest rate on the bond is given by the sum of return on a perpetuity and an exogenous additive term which is subject to a stochastic volatility shock:

$$R_t^B = \frac{(1/P_{t-1} + Q_t^B)}{Q_{t-1}^B} + \nu_{RB,t}, \tag{38}$$

where P_{t-1} is the overall price level in period $t-1$ and $\nu_{RB,t}$ is a shock to the realized return on government bonds. The law of motion for the latter evolves as:

$$\nu_{RB,t} = \rho_{RB}\nu_{RB,t-1} + e^{\sigma_{RB,t}} u_{RB,t}, \tag{39}$$

where $u_{RB,t}$ is a normally distributed shock with mean zero and unitary variance. Its standard deviation, $\sigma_{RB,t}$, obeys the following mean-reverting process:

$$\sigma_{RB,t} = (1 - \rho_{\sigma_{RB}})\sigma_{RB} + \rho_{\sigma_{RB}}\sigma_{RB,t-1} + \eta u_{\sigma_{RB,t}}. \tag{40}$$

In the previous equation, the shock $u_{\sigma_{RB,t}}$ is normally distributed with zero mean and unitary variance. This is what I refer to as a sovereign uncertainty shock. The parameters σ_{RB} and η control, respectively, the degree of mean volatility and stochastic volatility.

As introduced before, this approximation for sovereign uncertainty deserves to be discussed. It is clear that the previous equations do not look as if they model the possibility of a default by the government. In that case, there would simply be a binary variable multiplying the excess return. This is something in line with Bocola (2016), who examines the effects of shocks to (perceived) sovereign default risk on economic activity through financial intermediaries. In particular, he analyzes two different but complementary channels (liquidity and risk) under which a rise in the probability of default transmits into the financial and real sectors of the Italian economy. He finds that the risk channel accounts for up to 45 percent of the impact of the sovereign debt crisis on firms' borrowing costs.

In this paper, I do not separate the quantitative contributions of the two channels. The main objective of my theoretical analysis is to show whether a New Keynesian DSGE model with financial intermediation can effectively match the empirical evidence of an uncertainty shock originating from changes in the public financial sector, and if so, what theoretical assumptions are necessary to achieve this. In addition, I have opted for the stochastic volatility narrative of the exogenous additive term in the realized return on government debt for the following reason. As mentioned previously, during the extraction of the empirical measure of sovereign uncertainty, the one-step-ahead prediction error of each time series and of each selected factor in the FAVAR model exhibited time-varying volatility, where the latter was computed (for each forecast error) by employing an AR(1) stochastic volatility model. This feature allowed for a shock to the second moment that is independent of the first moment. Consequently, the way I model uncertainty in both sections is based on the same assumptions.[35] It is true, however, that the large set of information available in the empirical counterpart is not present here. I am thus constrained to simplify the diverse data-oriented stochastic volatility processes into a single stochastic volatility entity.

One could also argue that the European debt crisis resulted from a combination of the risk of default and the risk of leaving the Euro. Macera et al. (2022) develop a partial equilibrium model with two equations — a government budget constraint and a money demand — to assess the impact of information frictions, specifically through internal rationality, on the risk of hyperinflation following a departure from the Eurosystem. They show that a small deviation from rational expectations (RE) can lead to inflation rates several times higher than those predicted by RE. In contrast, my paper adheres to the RE framework but investigates the role of uncertainty about the outlook for public finances within a general equilibrium setting.

Summing up, the larger potential fluctuations in the real interest rate on sovereign bonds (either negative or positive) serve as a theoretical approximation for the data-driven sovereign uncertainty index. In this way, uncertainty about future movements related to the real return on government bonds affect agents' expectations and is able to generate fluctuations in nominal and real variables.

4.1.8 Monetary Policy and Equilibrium

The monetary authority sets the nominal interest rate following a simple Taylor rule:

$$\left(\frac{i_t}{i}\right) = \left(\frac{\pi_t}{\pi}\right)^{\kappa_\pi} \times \left(\frac{Y_t}{Y}\right)^{\kappa_Y}, \tag{41}$$

where i_t is the net nominal interest rate, i the steady state nominal interest rate and Y stands for output in steady state.

To fully reflect the view that the European Central Bank (ECB) will not change its nominal target by only observing the economic developments of the Spanish economy, one should take into account the Spanish contribution to Euro Area output and inflation. In the calibration part, I will then set the parameter governing the reaction to output growth close to zero. However, in a NK-DSGE model, a small weight on inflation leads to indeterminacy (see Galí, 2015). This is the reason why the latter will be set to a standard value in the literature.

The following Fisher equation relates the nominal and the real interest rates:

$$1 + i_t = \mathbb{E}_t R_{t+1} \frac{P_{t+1}}{P_t}. \tag{42}$$

[35]Further investigation (not shown) reveals that if I model sovereign uncertainty by simply considering a binary variable multiplying the excess return as in the literature on government default, this does not deliver hump-shaped responses in economic activity, which are observed in the empirical contribution of the paper after a sovereign uncertainty shock.

In addition, I consider that monetary policy decisions can be directly influenced by sovereign uncertainty shocks and augment the previous simple Taylor rule as follows:

$$\left(\frac{i_t}{i}\right) = \left(\frac{\pi_t}{\pi}\right)^{\kappa_\pi} \times \left(\frac{Y_t}{Y}\right)^{\kappa_Y} \times \left(\frac{e^{\sigma_{RB,t}}}{e^{\sigma_{RB}}}\right)^{\kappa_{\sigma_{RB}}}. \tag{43}$$

This modification follows Fernández-Villaverde et al. (2015) who also extend their model by allowing that the Federal Reserve is directly affected by fiscal volatility shocks. In this paper, the motivation is that the ECB has explicitly mentioned sovereign risk or fiscal uncertainty as a consideration for monetary policymaking during both the global financial crisis and the European debt crisis. Consequently, the previous specification allows for a smaller monetary policy easing than the one expected in an environment with no uncertainty about the future path of public finances. As demonstrated later, the inclusion of this feature will help to better quantitatively match the empirical IRFs.

It is worth mentioning that the assumption that the ECB's response can be altered in some circumstance due to SU shocks in Spain is not so restrictive. For instance, it is likely that the peak in the SU measure during the sovereign debt crisis is more due to global (European) factors than domestic (Spanish) factors. Therefore, the reaction of the ECB is more justified if one thinks on this specific episode.

Finally, the aggregate resource constraint is given by the following expression:

$$Y_t = C_t + \left[1 + f\left(\frac{I_t}{I_{t-1}}\right)\right] I_t + \frac{\phi_P}{2}\left[\frac{P_t}{P_{t-1}} - \pi\right]^2 Y_t. \tag{44}$$

The supply of long-term bonds is fixed by the government:

$$B_t = \bar{B}. \tag{45}$$

Labor market equilibrium requires that labor supply equals labor demand:

$$\frac{(1-\nu)}{\nu}\frac{C_t}{(1-H_t)} = P_{m,t}(1-\alpha)\frac{Y_t}{H_t}. \tag{46}$$

And the supply of firm's securities at the end of period t evolves as:

$$S_t = I_t + (1-\delta)K_t. \tag{47}$$

4.2 Solving the Model, Calibration, and Estimation

The model is solved by means of a third-order perturbation method. As explained in the study by Fernández-Villaverde et al. (2011), a third-order approximation to the equilibrium conditions of the model is required in order to allow that stochastic volatility shocks enter as independent arguments into the policy functions with coefficients different from zero.[36]

I divide the calibration of the model's parameters into two groups. In the first group, parameters are calibrated using results from the literature or steady state relationships.

[36] The non-linear solution of the model is conducted with Dynare (Adjemian et al. 2011). The pruning algorithm described in Andreasen et al. (2018) is used to account for non-explosive simulations.

For the second group, I estimate them using moment matching which I will detail later. Table 1 lists the parameters taken from both groups.[37]

I set the values of some parameters drawing upon Gertler and Karadi (2013): capital share in production for intermediate goods firms, α; proportional advantage in seizure rate of government bonds, Δ; capital holdings of households, S^h/S; and portfolio adjustment cost, κ. Transfer to new bankers, ω, is 0.001 (a small value similar to Gertler and Karadi, 2011). Following Gertler and Karadi (2013), I also choose values for the survival rate of

Table 1: Model Parameters

	Firms		
ϑ	Investment adjustment cost	84.82	Target
δ	Gross depreciation rate	0.02	Standard
α	Capital share in production	0.33	Gertler and Karadi (2013)
ϵ	Elasticity of demand	9	Burriel et al. (2010)
ϕ_P	Price adjustment cost	100	Price stickiness of 0.75
	Banks		
λ	Fraction of divertible capital	0.38	Leverage ratio for banks of six
ω	Transfer to new bankers	0.001	Small value
θ	Survival rate of bankers	0.98	Horizon of around ten years
Δ	Seizure rate of gov. bonds	0.50	Gertler and Karadi (2013)
	Households		
β	Discount rate	0.992	Real interest rate of about 3%
σ	Risk aversion	5	Caldara et al. (2012)
ψ	Inter. elasticity of substitution	0.50	Caldara et al. (2012)
$\bar{B}^h/\bar{B}$	Bond holdings by households	0.70	Data
$\bar{S}^h/\bar{S}$	Capital holdings of households	0.50	Gertler and Karadi (2013)
κ	Portfolio adjustment cost	1	Gertler and Karadi (2013)
	Monetary Policy and Bond Supply		
κ_π	Inflation coefficient TR	1.50	Standard
κ_y	Output coefficient TR	0.05	Low value
$\kappa_{\sigma_{RB}}$	Sov. uncertainty coefficient TR	0.007	Low value
$\bar{B}$	Government bond supply	1.15	Data ($B/Y = 0.60$)
	Shocks		
$\rho_{\sigma_{RB}}$	Autocorrelation parameter of σ_{Rb}	0.80	VAR evidence
η	Stochastic volatility parameter	0.33	VAR evidence
ρ_{RB}	Autocorrelation parameter of Rb	0.882	Target
σ_{RB}	Degree of mean volatility	-6.88	Target
ρ_ξ	Capital quality autocorrelation	0.965	Target
σ_ξ	S.D. of capital quality shock	0.030	Target

bankers, θ, and for the fraction of divertible capital, λ, to hit the following targets: an expected horizon of around ten years for banker, and a steady-state leverage ratio for banks of six. The parameter for elasticity of demand, ϵ, comes from Burriel et al. 2010, who estimate it for the Spanish economy in particular. The risk aversion parameter, σ, and the intertemporal elasticity of substitution parameter, ψ, are obtained from Caldara et al. (2012). Price adjustment cost, ϕ_P, is chosen to be 100 so that in a first-order equivalent

[37] Christiano et al. (2005) and Basu and Bundick (2017) use a similar estimation approach.

Calvo (1983) setup, prices are fixed for four quarters on average. The household discount factor, β, is given a standard value of 0.992 (annualized real interest rate of about 3 percent). The share of bond holdings by households, $\bar{B}^h/\bar{B}$, is set to 0.70 as observed in the data (see Merler and Pisani-Ferry, 2012). Government bond supply, $\bar{B}$, is set to hit the ratio of government debt to output (around 0.60, average 1997–2017). For monetary policy, the value for $\kappa_\pi = 1.50$ is standard and largely used in the literature, and $\kappa_y = 0.05$ as argued before. To account for uncertainty about the future path of public finances, I set $\kappa_{\sigma_{RB}}$ to a low value, following the modeling approach of Fernández-Villaverde et al. (2015) in handling fiscal volatility shocks. The values for the autocorrelation of the shock to the approximation process of sovereign uncertainty, $\rho_{\sigma_{RB}}$, and its stochastic volatility component, η, are set from the estimated VAR.[38]

As discussed, for the second group of parameters I employ a moment matching approach. Specifically, I define the estimator j as:

$$j = \min_{\gamma}[\hat{\Xi} - \Xi(\gamma)]' W^{-1} [\hat{\Xi} - \Xi(\gamma)], \tag{48}$$

where γ is the vector of estimated parameters. I refer to their estimated values as "target" in Table 1. $\hat{\Xi}$ and $\Xi(\gamma)$ are the vectors that contain, respectively, the unconditional standard deviations (and relative to output) of the selected variables in the data and in the model. The targeted variables are output, consumption, investment, hours worked and bank lending. W is a diagonal weighting matrix.

Table 2: Business Cycle Statistics: Model versus Data

Unconditional Volatility	Percent		Relative to Output	
	Model	Data	Model	Data
Targeted Variables				
Output	1.33	1.25	1	1
Consumption	1.37	1.46	1.03	1.17
Investment	3.56	3.57	2.67	2.86
Hours Worked	1.79	1.52	1.34	1.22
Bank Lending	3.39	3.33	2.55	2.66
Non-Targeted Variables				
Inflation	0.36	0.59	0.27	0.47
Nominal Rate	0.36	0.46	0.27	0.37
Credit Spread	0.72	0.79	0.54	0.63
Bond Spread	0.49	0.88	0.37	0.70

Note: The empirical sample period is 1997–2019. *Non-Targeted Variables* are the ones that are not included in the matching estimation. See Appendix A.1.3 and A.1.4 for data description and sources. For constructing data moments, I apply the HP filter to the log of each empirical time series with a smoothing factor of 1600. To compute the model-based moments, I first simulate the DSGE model for 25,000 periods (quarters) and compute the model moments after an initial burn-in period. I repeat this procedure 100 times to take the mean of the moments of the simulation.

[38] Notice that the path of the model's sovereign uncertainty process after the shock must be comparable to one obtained in the VAR analysis. For that reason, the parameters governing the stochastic process of sovereign uncertainty are set from the VAR evidence.

As a diagnosis of the model fit, Table 2 shows the moments observed in the data and those that are obtained from the model. Undoubtedly, the model does a good job at matching the empirical moments. The standard deviations of output, consumption, investment, hours worked and bank loans in the model are 1.33, 1.37, 3.56, 1.79 and 3.39 respectively, which are close to the values 1.25, 1.46, 3.57, 1.52 and 3.33 produced by the data. Moreover, Table 2 displays the standard deviations of the non-targeted variables in the model. Again, the theoretical framework is also able to reasonably match the standard deviations implied by the data.

4.3 Results

How well do the model-generated impulse responses match those from the empirical counterpart? First, I have to re-consider the VAR estimation in previous sections since the DSGE model is designed in quarterly terms. Figure 42 in Appendix B.1 displays three variants of the quarterly VAR. The benchmark vector includes consumer and industrial confidence, stock market index, bank loans, output, consumption, investment, price inflation, employment level, long-term interest rate on government bonds and sovereign uncertainty. This resembles the baseline recursive ordering in the previous empirical exercise (solid-blue lines). Furthermore, I also consider sovereign uncertainty as a more exogenous driver (marked-red lines) and the scenario where both sovereign and macro-financial uncertainties are present (dash-dot-purple lines). While the second recursive setup permits clear isolation of the economic mechanisms driving the propagation of sovereign uncertainty, the third accounts for this isolation and at the same time permits the purging of the effects of sovereign uncertainty shocks. I believe that, for the same reasons outlined in the previous sections, the last variation of the quarterly VAR is the most accurate representation. The selected vector of variables is then formed by bank loans, output, consumption, investment and hours worked.

Figure 7 exhibits the IRFs to a one standard deviation shock to sovereign uncertainty in the DSGE model and in the VAR setting.[39] Looking at the theoretical responses, output, consumption, investment, hours worked and bank lending fall persistently. Furthermore, the model is capturing most of the empirical slowdown in output, investment and hours worked, and in a lower proportion, it also accounts for the declines in consumption and bank lending while being consistent with the data moments (see Table 2) and with the empirical path of sovereign uncertainty after a shock to it. It is worth noting that for consumption and bank lending their respective theoretical responses lie inside the credible bands of the VAR framework for several quarters after the shock.

One interpretation of these results is that, after a sovereign uncertainty shock, the price of government bonds decline because now it becomes riskier to hold them as banks start to be exposed to larger fluctuations in the real return on government bonds (either negative or positive). At the same time, two more facts emerge: (*i*) heightened sovereign uncertainty affects banks' expectations on firms' claims causing a fall in the relative price of private capital too, and (*ii*) since banks are facing tighter funding constraints, the

[39] The theoretical IRFs are expressed in percent deviation from the stochastic steady state of the model. To construct these responses, I follow Basu and Bundick (2017) by setting the exogenous shocks in the model to zero and iterating the third-order solution forward. After a sufficient number of periods, the variables in the model converge to a fixed point, which is denoted as the stochastic steady state. Then, the economy is hit with only a one standard deviation SU shock and the IRFs are computed as the percent deviation between the equilibrium responses and the pre-shock stochastic steady state.

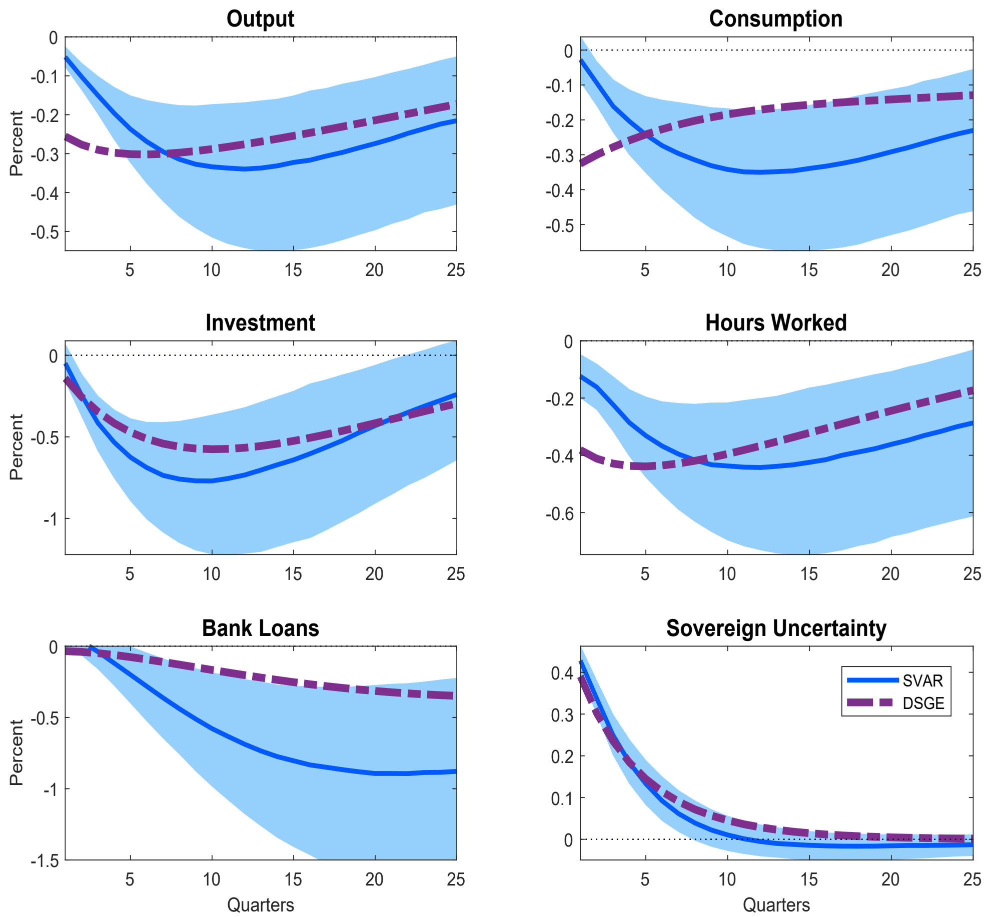

Figure 7: Quarterly IRFs to One Standard Deviation Shock to Sovereign Uncertainty: Model vs Data

Note: All responses are in quarterly percent deviations from the stochastic steady state.

marginal value of wealth is higher. The two forces together with the decline in the price of bonds amplify the drop in bank net worth. Consequently, banks' ability to lend to firms is severely limited since their credit capacity is directly tied to their net worth. Therefore, lack of sufficient bank credit creates scarcity of capital for firms and restricts real economic activity. Figure 8 (solid-purple lines) accounts for the previous dynamics and also shows that net worth recovers faster than bank assets, generating a slow recovery in real variables. Then, as already noted in Gertler and Karadi (2011), the need for deleveraging can delay the recovery of the economy.

Motivated by the slow recovery observed in the benchmark findings, I explore what the main drivers are that give rise to the persistence of the responses. I conduct several experiments. First, I reduce the reaction parameter to SU shocks in the Taylor rule from 0.007 to 0.002. In this way, the monetary policy decisions are directly less influenced by SU shocks. Figure 8 (dashed-black lines) shows the IRFs under this alternative scenario. As it can be seen, the results are qualitatively the same but the size of the responses is now smaller and the dynamics are less persistent. Nevertheless, output still falls by around -0.1% and investment by -0.16%.

The intuition of this experiment is as follows: if the reaction parameter to a SU shock in the Taylor rule is reduced, the monetary authority will not increase the nominal interest rate more than it would otherwise do so.[40] This will then alleviate the initial negative effects of sovereign uncertainty, and aggregate demand and inflation will decline to a lesser extent. The dynamics of net worth and the relative prices of different assets in the model also return to equilibrium faster than before, with signs of a rebound in the response of net worth. Then, firms build up their demand for capital and labour once uncertainty has started to shrink in the financial sector.

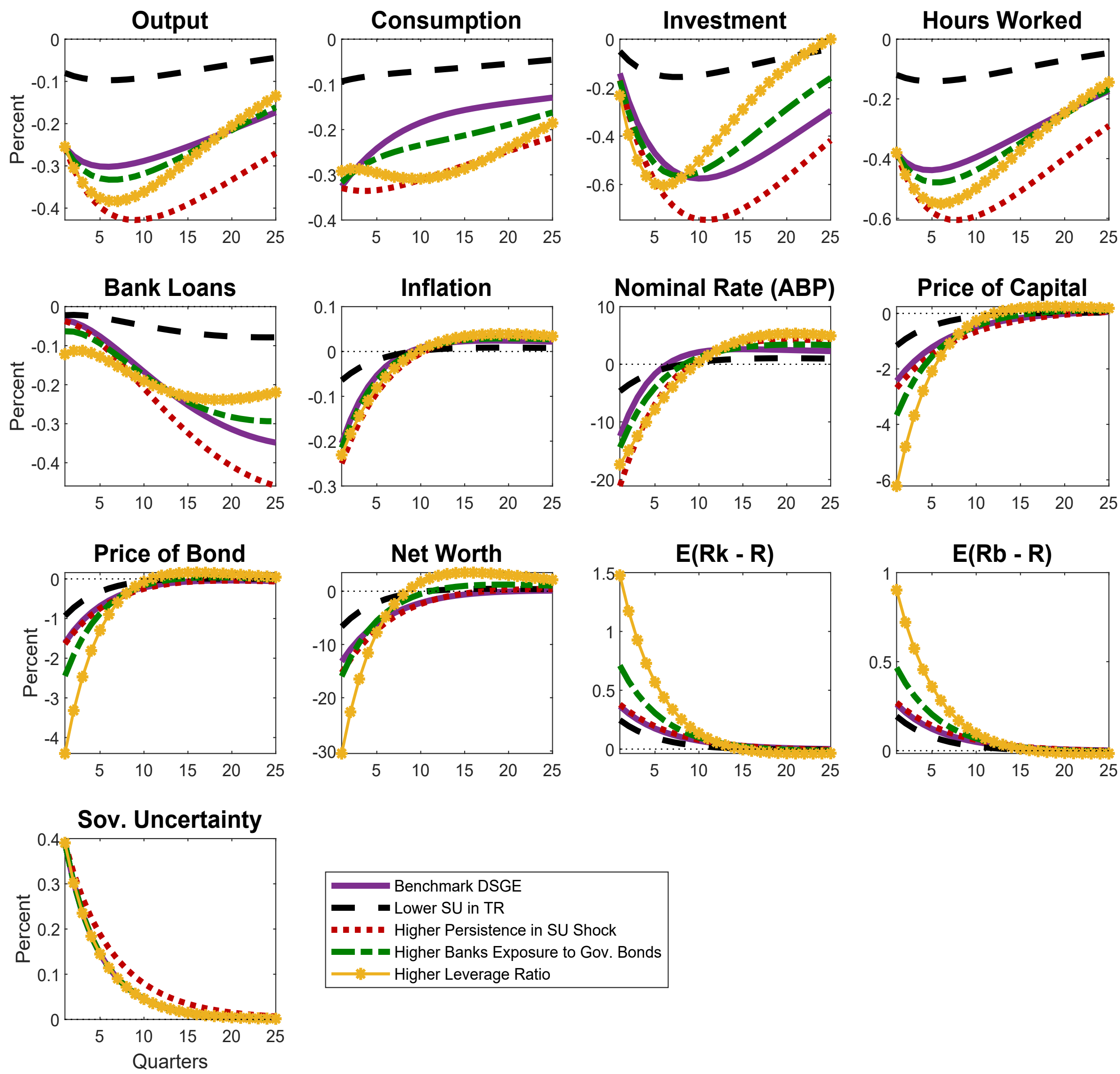

Figure 8: Quarterly IRFs to One Standard Deviation Shock to Sovereign Uncertainty: DSGE Model

Note: All responses are in quarterly percent deviations from the stochastic steady state, except for inflation and the nominal interest rate, which are expressed in quarterly percentage points and annualized basis points (ABP), respectively.

[40] In contrast, when one increases the value of the central bank's reaction parameter to SU shocks, $\kappa_{\sigma_{RB}}$, the model implies that the monetary authority has to react proportionally less in the aftermath of an SU shock relative to output and inflation responses. As stated before, the monetary authority will react by decreasing the nominal interest rate after this adverse shock, but it will potentially do so more cautiously given the presence of higher uncertainty in the economy.

In what follows, the second experiment consists of slightly increasing the persistence of the SU shock from 0.80 to 0.85 (dotted-red lines in Figure 8). This rise does not change much the model moments and clearly produce larger responses. On the one hand, the effects on output, consumption, investment, hours worked and bank lending are more persistent than those under the benchmark estimation. On the other hand, even if this small change in the persistence of the shock does not perturb much the standard deviations of the selected variables in the model, it does affect the theoretical path of sovereign uncertainty after the shock, falling outside the empirical 68% credible bands.[41]

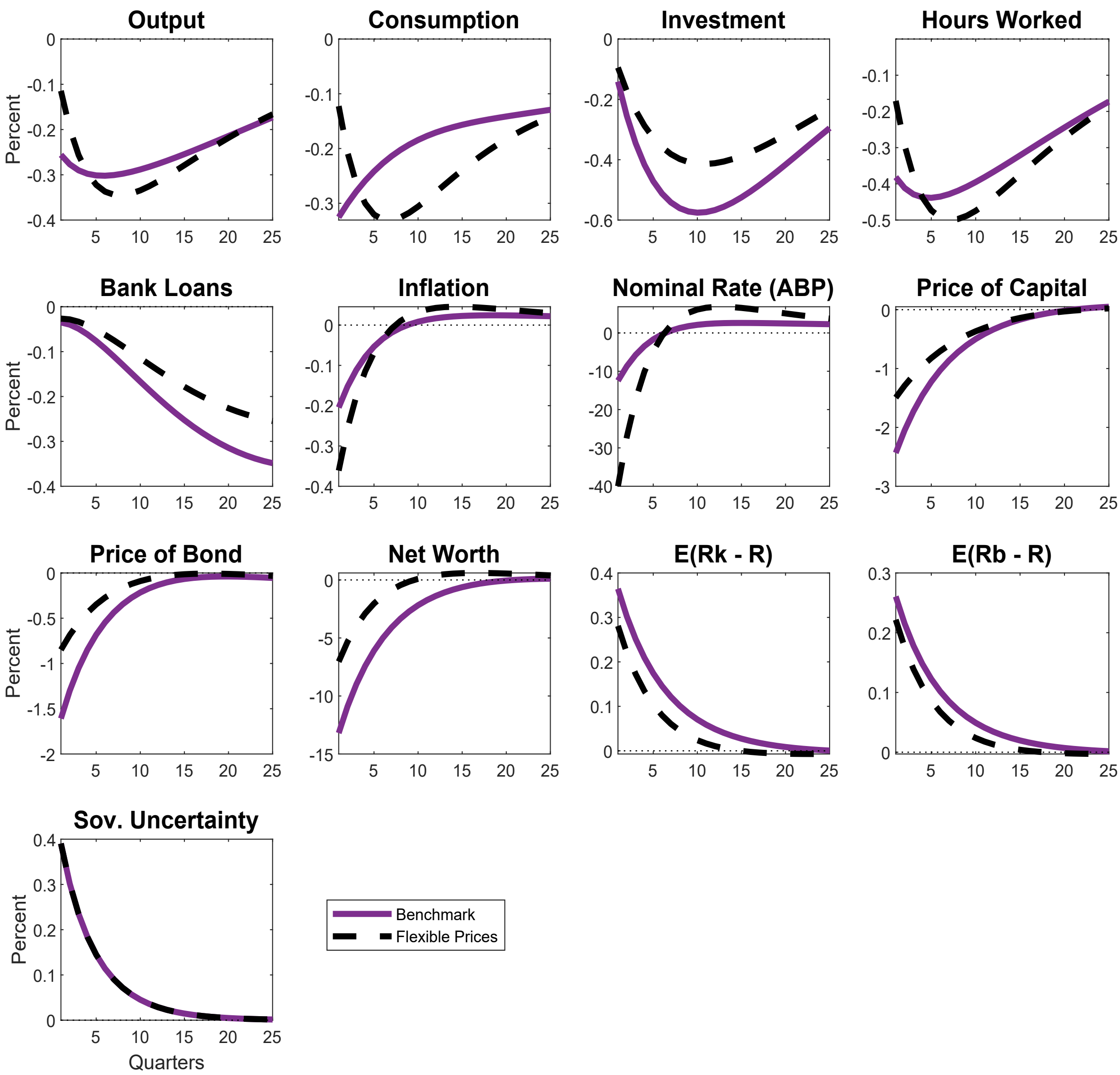

Figure 9: Quarterly IRFs to One Standard Deviation Shock to Sovereign Uncertainty: Flexible Prices

Note: All responses are in quarterly percent deviations from the stochastic steady state, except for inflation and the nominal interest rate, which are expressed in quarterly percentage points and annualized basis points (ABP), respectively.

[41]On the contrary, at the 90% or 95%, it would be falling inside.

The third exercise focuses on higher banks' exposure to government bonds. In particular, Figure 8 (dash-dot-green lines) shows the implications of a SU shock when banks hold 50% of total government bonds ($\bar{B}^h/\bar{B} = 0.50$) instead of 30% ($\bar{B}^h/\bar{B} = 0.70$). As observed, the responses are larger. The results are primarily amplified because government bonds now constitute a higher share in banks' portfolios, and in the aftermath of a SU shock, banks are then more exposed to uncertain fluctuations in the real return on these bonds. This implies more impaired balance sheets and banks reduce lending further.

The fourth experiment consists of setting $\lambda = 0.25$. Thus, I can simulate a scenario in which the bank's leverage ratio increases, mirroring the high values observed during the Great Recession. In this case, Figure 8 (asterisk-yellow lines) confirms that the DSGE model can generate larger responses than in the benchmark scenario. The increased leverage ratio amplifies the impact of asset price fluctuations on bank net worth and, consequently, on the pass-through to the real economy.[42]

Next, I investigate the role that nominal rigidities play in explaining the detrimental effects of sovereign uncertainty shocks. Figure 9 shows that the results under flexible prices ($\phi_P = 0$) are definitely smaller, especially upon impact, than in the baseline case ($\phi_P = 100$). Yet, this difference is much less pronounced than in the previous literature where, in the absence of nominal rigidities, the effects in economic activity are negligible (see Bloom, 2009 and Basu and Bundick, 2017). The intuition is that this literature has generally focused on uncertainty shocks arising from the real economy (second-moment shocks to households' preferences or to total factor productivity) and in a framework that abstracts from financial intermediaries. In this paper, the source of uncertainty is originating from government finances and in an environment with financial frictions. Consequently, this result implies that the presence of financial frictions can be enough to account for large declines in economic aggregates. A recent paper by Gilchrist et al. (2014) raises this point, indicating that financial frictions are a powerful conduit through which uncertainty shocks affect economic activity.[43]

In the empirical dimension, I have discussed the diverse impacts stemming from SU and MU shocks. Now, I proceed to compare the effects of a SU shock with those resulting from simulating a MU shock in the theoretical model.[44] I proxy macroeconomic uncertainty with second-moment shocks to TFP, following the approach of Caldara et al. (2012) and Cesa-Bianchi and Fernandez-Corugedo (2018):

$$A_t = \rho_A A_{t-1} + e^{\sigma_{A,t}} u_{A,t}, \tag{49}$$

where $u_{A,t}$ is normally distributed with mean zero and unitary variance. Its standard deviation, $\sigma_{A,t}$, obeys the following AR(1) process:

[42] I can also simulate a scenario in which the bank's leverage ratio increases, but SU shocks do not directly affect the Taylor rule. This results in a more pronounced impact, closer to the baseline IRFs (see Figure 43 in Appendix B.2). However, if monetary policy decisions can be directly influenced by sovereign uncertainty shocks, this allows us to match the VAR evidence with much lower leverage ratios.

[43] Bonciani and van Roye (2016) also highlight the importance of financial frictions. However, given that their uncertainty shock is coming from the real sector — a volatility shock to households' preferences — the negative co-movement between output, consumption and investment is not longer present under flexible prices.

[44] In Appendix B.4, I also simulate the theoretical model and subsequently estimate structural VARs using the simulated data.

$$\sigma_{A,t} = (1 - \rho_{\sigma_A})\sigma_A + \rho_{\sigma_A}\sigma_{A,t-1} + \eta_A u_{\sigma_{A,t}}. \tag{50}$$

The MU shock, $u_{\sigma_{RB,t}}$, follows a normal distribution with a mean of zero and a variance of one. Similar to the case of sovereign uncertainty, the parameters σ_A and η_A govern the degree of mean volatility and stochastic volatility, respectively. I set $\rho_A = 0.95$ and $\log \sigma_A = 0.0064$, derived from the properties of the Solow residual (see Comin et al., 2023). For the stochastic volatility process, I select the same size of the shock as in the case of sovereign uncertainty, i.e., $\eta_A = 0.33$, and perform a sensitivity analysis with the persistence of the shock. Thus, the following analysis provides further insights into the mechanisms and identification performed in the empirical section.

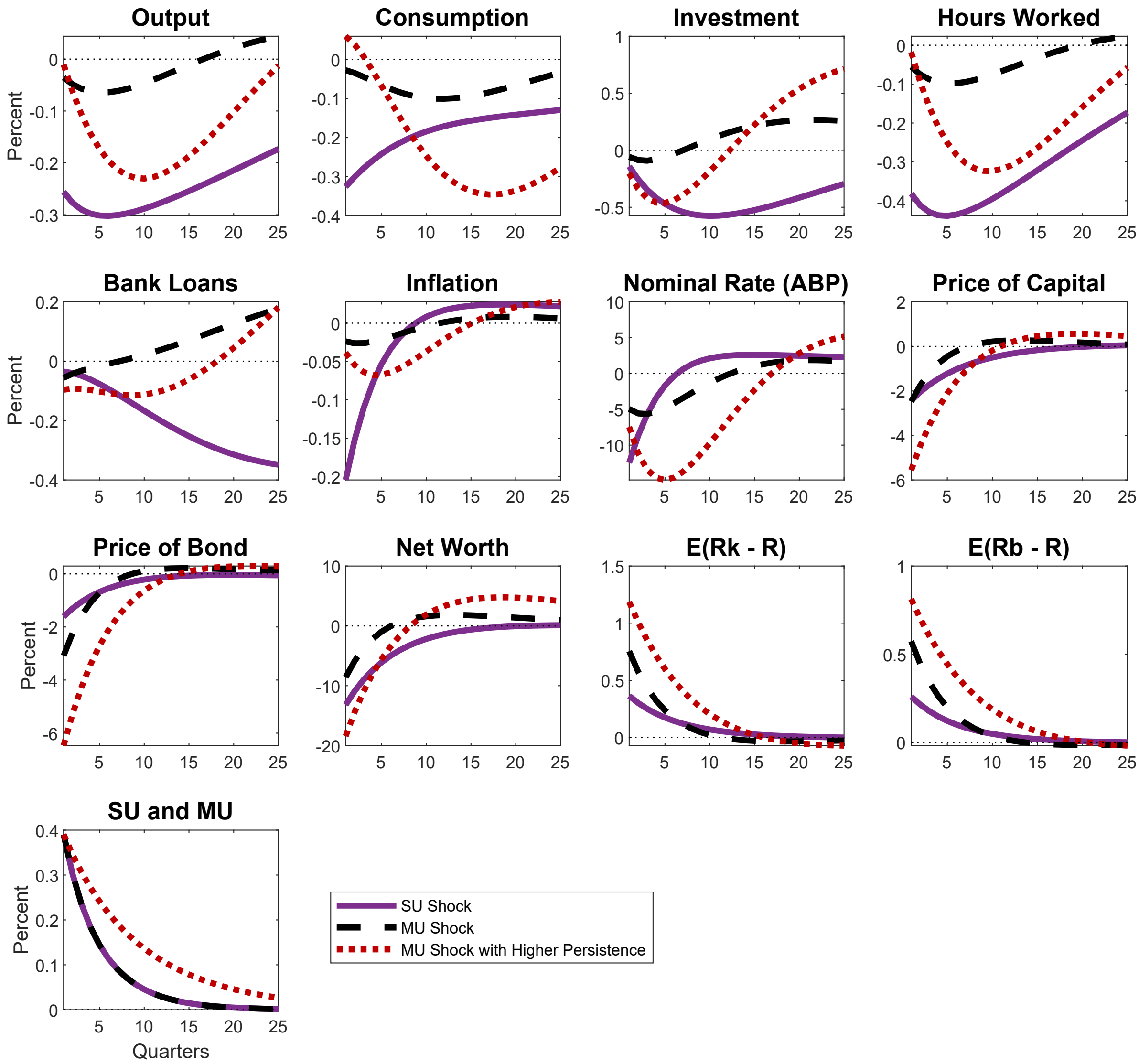

Figure 10: Quarterly IRFs to One Standard Deviation Shock to SU and MU

Note: All responses are in quarterly percent deviations from the stochastic steady state, except for inflation and the nominal interest rate, which are expressed in quarterly percentage points and annualized basis points (ABP), respectively.

Figure 10 displays the responses to both uncertainty shocks. Similarly to a sovereign uncertainty shock, heightened uncertainty regarding future technology can lead to a downturn in both the financial and real sectors. A significant difference noted in the narrative VAR section was the greater persistence implied by SU shocks compared to MU shocks. As observed in the DSGE model, whether the persistence of the MU shock matches that of the SU shock ($\rho_{\sigma_A} = 0.80$, dashed-black lines) or is higher ($\rho_{\sigma_A} = 0.90$, dotted-red lines), MU shocks consistently exhibit less persistence than SU shocks, aligning with the predictions of the VAR analysis.[45] On the one hand, in response to an uncertainty shock about the future path of public finances, the monetary authority lowers the nominal interest rate. However, this proves insufficient to offset the contractionary effects of heightened sovereign uncertainty. In contrast, following a MU shock, the central bank's reaction is much more pronounced, even with a smaller movement in inflation. On the other hand, another consequence linked to the lack of persistence from the MU shock is the generation of an overshooting effect in investment, which has been detected in other theoretical and empirical studies (see Bloom, 2009 and Caggiano et al., 2014). This feature comes from the dynamics of net worth and bank lending, which return to equilibrium much faster than before with clear rebounds in their responses.

5 Conclusion

Several recent episodes in Europe have stressed again that the outlook for government finances is far from being certain. In this paper, I first present a new uncertainty indicator for public finances, which I refer to as *sovereign uncertainty* (SU), by exploiting a high-information content approach. The estimated measure identifies important government-related events for the Spanish economy and is distinct from macro-financial and economic policy uncertainty indices.

Next, I empirically assess the implications of unexpected increases in sovereign uncertainty on economic activity. According to my BVAR analysis, shocks to SU that are identified through both recursive orderings and a combination of sign, event-based and ratio restrictions lead to economically and statistically significant negative effects in the financial and macroeconomic sectors. In addition, I show that the impact of a sovereign uncertainty shock differs from a macro-financial uncertainty shock originating from disturbances in the private sector — while the former persistently affects the economy in the medium-run, the latter exhibits limited impact on real activity.

Finally, I study the transmission of sovereign uncertainty in a canonical New Keynesian DSGE model augmented with financial intermediation and Epstein-Zin preferences. I find that the proposed theoretical model captures the empirical slowdown in output, investment and hours worked following a SU shock and, in a lower proportion, it also accounts for the declines in consumption and bank lending while being consistent with the data moments and with the empirical path of sovereign uncertainty after a shock to it. In order to achieve this full matching, lack of reaction by the monetary authority is pivotal. My theoretical framework also emphasizes the importance of financial frictions in explaining and transmitting the effects of sovereign uncertainty shocks and highlights the minor role played by nominal rigidities.

[45] Values for ρ_{σ_A} greater than 0.9 imply excessive unconditional volatility in macroeconomic aggregates.

References

Adjemian, Stéphane, Houtan Bastani, Michel Juillard, Ferhat Mihoubi, George Perendia, Marco Ratto and Sébastien Villemot. (2011). "Dynare: Reference manual, version 4". Dynare Working Papers, 1, CEPREMAP. https://www.dynare.org/wp-repo/dynarewp001.pdf

Alcidi, Cinzia, and Daniel Gros. (2018). *Debt Sustainability Assessments: The state of the art.* (European Parliament in-depth analysis, PE-624.426). European Parliament. https://www.europarl.europa.eu/RegData/etudes/IDAN/2018/624426/IPOL_ IDA(2018)624426_EN.pdf

Alessandri, Piergiorgio, and Haroon Mumtaz. (2019). "Financial regimes and uncertainty shocks". *Journal of Monetary Economics*, 101, pp. 31-46. https://doi.org/10.1016/j.jmoneco.2018.05.001

Andreasen, Martin M., Jesús Fernández-Villaverde and Juan F. Rubio-Ramírez. (2018). "The Pruned State-Space System for Non-Linear DSGE Models: Theory and Empirical Applications". *Review of Economic Studies*, 85(1), pp. 1-49. https://doi.org/10.1093/restud/rdx037

Antolín-Díaz, Juan, and Juan F. Rubio-Ramírez. (2018). "Narrative sign restrictions for SVARs". *American Economic Review*, 108(10), pp. 2802-2829. https://doi.org/10.1257/aer.20161852

Anzuini, Alessio, Luca Rossi and Pietro Tommasino. (2020). "Fiscal policy uncertainty and the business cycle: Time series evidence from Italy". *Journal of Macroeconomics*, 65(103238). https://doi.org/10.1016/j.jmacro.2020.103238

Arellano, Cristina. (2008). "Default risk and income fluctuations in emerging economies". *American Economic Review*, 98(3), pp. 690-712. https://doi.org/10.1257/aer.98.3.690

Auerbach, Alan J., and Yuriy Gorodnichenko. (2012). "Measuring the output responses to fiscal policy". *American Economic Journal: Economic Policy*, 4(2), pp. 1-27. https://doi.org/10.1257/pol.4.2.1

Bai, Jushan, and Serena Ng. (2002). "Determining the number of factors in approximate factor models". *Econometrica*, 70(1), pp. 191-221. https://doi.org/10.1111/1468-0262.00273

Baker, Scott R., Nicholas Bloom and Steven J. Davis. (2016). "Measuring Economic Policy Uncertainty". *The Quarterly Journal of Economics*, 131(4), pp. 1593-1636. https://doi.org/10.1093/qje/qjw024

Bánbura, M., D. Giannone and L. Reichlin. (2010). "Large bayesian vector auto regressions". *Journal of Applied Econometrics*, 25, pp. 71-92. https://doi.org/10.1002/jae.1137

Banco de España. Servicio de Estudios. (2006). *The analysis of the Spanish economy: data, instruments and procedures.* Banco de España. https://repositorio.bde.es/handle/123456789/15829

Basu, Susanto, and Brent Bundick. (2017). "Uncertainty shocks in a model of effective demand". *Econometrica*, 85, pp. 937-958.

Berger, Tino, Sibylle Grabert and Bernd Kempa. (2016). "Global and Country-Specific Output Growth Uncertainty and Macroeconomic Performance". *Oxford Bulletin of Economics and Statistics*, 78(5), pp. 694-716. https://doi.org/10.1111/obes.12118

Bernanke, Ben S. (1983). "Irreversibility, uncertainty, and cyclical investment". *The Quarterly Journal of Economics*, 98(1), pp. 85-106. https://doi.org/10.2307/1885568

Bi, Huixin. (2012). "Sovereign default risk premia, fiscal limits, and fiscal policy". *European Economic Review*, 56(3), pp. 389-410. https://doi.org/10.1016/j.euroecorev.2011.11.001

Bloom, Nicholas. (2009). "The Impact of uncertainty shocks". *Econometrica*, 77(3), pp. 623-685. https://doi.org/10.3982/ECTA6248

Bloom, Nicholas. (2014). "Fluctuations in uncertainty". *Journal of Economic Perspectives*, 28(2), pp. 153-76. https://doi.org/10.1257/jep.28.2.153

Bocola, Luigi. (2016). "The pass-through of sovereign risk". *Journal of Political Economy*, 124(4), pp. 879-926. https://doi.org/10.1086/686734

Bonciani, Dario, and Björn van Roye. (2016). "Uncertainty shocks, banking frictions and economic activity". *Journal of Economic Dynamics and Control*, 73, pp. 200-219. https://doi.org/10.1016/j.jedc.2016.09.008

Born, Benjamin, and Johannes Pfeifer. (2014). "Policy risk and the business cycle". *Journal of Monetary Economics*, 68, pp. 68-85. https://doi.org/10.1016/j.jmoneco.2014.07.012

Burriel, Pablo, Jesús Fernández-Villaverde and Juan F. Rubio-Ramírez. (2010). "MEDEA: a DSGE model for the Spanish economy". *SERIEs*, 1(1), pp. 175-243. https://doi.org/10.1007/s13209-009-0011-x

Burriel, Pablo, Javier J. Pérez and Ivan Kataryniuk. (2023). "Computing the EU's SURE Interest Savings with an Extended Debt Sustainability Analysis Tool". *Hacienda Pública Española / Review of Public Economics*, 245(2), pp. 157-178. https://doi.org/10.7866/HPE-RPE.23.2.6

Caggiano, Giovanni, Efrem Castelnuovo, Silvia Delrio and Richard Kima. (2020). "Financial Uncertainty and Real Activity: The Good, the Bad, and the Ugly". CESifo Working Paper Series, 8426, CESifo. https://doi.org/10.2139/ssrn.3653951

Caggiano, Giovanni, Efrem Castelnuovo and Juan Manuel Figueres. (2017). "Economic policy uncertainty and unemployment in the United States: A nonlinear approach". *Economics Letters*, 151, pp. 31-34. https://doi.org/10.1016/j.econlet.2016.12.002

Caggiano, Giovanni, Efrem Castelnuovo and Nicolas Groshenny. (2014). "Uncertainty Shocks and Unemployment Dynamics in U.S. Recessions". *Journal of Monetary Economics*, 67, pp. 78-92. https://doi.org/10.1016/j.jmoneco.2014.07.006

Caldara, Dario, Jesús Fernández-Villaverde, Juan Rubio-Ramírez and Wen Yao. (2012). "Computing DSGE Models with Recursive Preferences and Stochastic Volatility". *Review of Economic Dynamics*, 15(2), pp. 188-206. https://doi.org/10.1016/j.red.2011.10.001

Calvo, Guillermo A. (1983). "Staggered prices in a utility-maximizing framework". *Journal of Monetary Economics*, 12(3), pp. 383-398. https://doi.org/10.1016/0304-3932(83)90060-0

Canova, Fabio, and Gianni De Nicoló. (2002). "Monetary disturbances matter for business fluctuations in the G-7". *Journal of Monetary Economics*, 49(6), pp. 1131-1159. https://doi.org/10.1016/S0304-3932(02)00145-9

Carriero, Andrea, Todd E. Clark and Massimiliano Marcellino. (2018). "Endogenous Uncertainty". Working Papers, 18-05, Federal Reserve Bank of Cleveland. https://doi.org/10.26509/frbc-wp-201805

Cascaldi-García, Danilo, and Ana Beatriz Galvao. (2018). "News and uncertainty shocks". International Finance Discussion Papers, 1240r, Board of Governors of the Federal Reserve System. https://doi.org/10.17016/ifdp.2018.1240

Castelnuovo, Efrem. (2023). "Uncertainty before and during COVID-19: A survey". *Journal of Economic Surveys,* 37(3), pp. 821-864. https://doi.org/10.1111/joes.12515

Cesa-Bianchi, Ambrogio, and Emilio Fernandez-Corugedo. (2018). "Uncertainty, financial frictions, and nominal rigidities: A quantitative investigation". *Journal of Money, Credit and Banking,* 50(4), pp. 603-636. https://doi.org/10.1111/jmcb.12505

Cesa-Bianchi, Ambrogio, M. Hashem Pesaran and Alessandro Rebucci. (2019). "Uncertainty and Economic Activity: A Multicountry Perspective". *The Review of Financial Studies,* 33(8), pp. 3393-3445. https://doi.org/10.1093/rfs/hhz098

Chen, C. W. S., and J. C. Lee. (1995). "Bayesian inference of threshold autoregressive models". *Journal of Time Series Analysis,* 16, pp. 483-492. https://doi.org/10.1111/j.1467-9892.1995.tb00248.x

Christiano, Lawrence J., Martin Eichenbaum and Charles L. Evans. (2005). "Nominal rigidities and the dynamic effects of a shock to monetary policy". *Journal of Political Economy,* 113(1), pp. 1-45. https://doi.org/10.1086/426038

Christiano, Lawrence J., Roberto Motto and Massimo Rostagno. (2014). "Risk shocks". *The American Economic Review,* 104(1), pp. 27-65. https://doi.org/10.1257/aer.104.1.27

Comin, Diego A., Javier Quintana, Tom G. Schmitz and Antonella Trigari. (2023). "Revisiting Productivity Dynamics in Europe: A New Measure of Utilization-Adjusted TFP Growth". NBER Working Paper Series, 31006, National Bureau of Economic Research. https://doi.org/10.3386/w31006

Faust, Jon. (1998). "The robustness of identified VAR conclusions about money". International Finance Discussion Papers, 610, Board of Governors of the Federal Reserve System. https://doi.org/10.2139/ssrn.86751

Fernández-Villaverde, Jesús, and Pablo A. Guerrón-Quintana. (2020). "Uncertainty shocks and business cycle research". *Review of Economic Dynamics,* 37(1), pp. S118-S146. https://doi.org/10.3386/w26768

Fernández-Villaverde, Jesús, Pablo Guerrón-Quintana, Keith Kuester and Juan Rubio-Ramírez. (2015). "Fiscal volatility shocks and economic activity". *The American Economic Review,* 105(11), pp. 3352-3384. https://doi.org/10.1257/aer.20121236

Fernández-Villaverde, Jesús, Pablo Guerrón-Quintana, Juan F. Rubio-Ramírez and Martin Uribe. (2011). "Risk matters: The real effects of volatility shocks". *The American Economic Review,* 101(6), pp. 2530-2561. https://doi.org/10.1257/aer.101.6.2530

Forni, Mario, Luca Gambetti and Luca Sala. (2017). "News, Uncertainty and Economic Fluctuations (No News is Good News)". CEPR Discussion Papers, 12139, CEPR Press. https://cepr.org/publications/dp12139

Furlanetto, Francesco, Francesco Ravazzolo and Samad Sarferaz. (2019). "Identification of Financial Factors in Economic Fluctuations". *Economic Journal,* 129(617), pp. 311-337. https://doi.org/10.1111/ecoj.12520

Galí, Jordi. (2015). *Monetary policy, inflation and the business cycle: An introduction to the New Keynesian framework and its applications.* Princeton University Press.

Gertler, Mark, and Peter Karadi. (2011). "A model of unconventional monetary policy". *Journal of Monetary Economics,* 58(1), pp. 17-34. https://doi.org/10.1016/j.jmoneco.2010.10.004

Gertler, Mark, and Peter Karadi. (2013). "QE 1 vs. 2 vs. 3. . . : A Framework for Analyzing Large-Scale Asset Purchases as a Monetary Policy Tool". *International Journal of Central Banking,* 9(1), pp. 5-53. https://www.ijcb.org/journal/ijcb13q0a1.pdf

Ghirelli, Corinna, Javier J. Pérez and Alberto Urtasun. (2019). "A new economic policy uncertainty index for Spain". Documentos de Trabajo, 1906, Banco de España. https://repositorio.bde.es/handle/123456789/8820

Gilchrist, Simon, and Benoit Mojon. (2018). "Credit Risk in the Euro Area". *Economic Journal,* 128(608), pp. 118-158. https://doi.org/10.1111/ecoj.12427

Gilchrist, Simon, Jae W. Sim and Egon Zakrajsek. (2014). "Uncertainty, Financial Frictions, and Investment Dynamics". NBER Working Paper Series, 20038, National Bureau of Economic Research. https://doi.org/10.3386/w20038

Jurado, Kyle, Sydney C. Ludvigson and Serena Ng. (2015). "Measuring uncertainty". *American Economic Review,* 105(3), pp. 1177-1216. https://doi.org/10.1257/aer.20131193

Kilian, L., and R. J. Vigfusson. (2011). "Are the responses of the U.S. economy asymmetric in energy price increases and decreases?". *Quantitative Economics,* 2, pp. 419-453. https://doi.org/10.3982/QE99

Koop, G. M., M. H. Pesaran and S. M. Potter. (1996). "Impulse response analysis in nonlinear multivariate models". *Journal of Econometrics,* 74, pp. 119-147. https://doi.org/10.1016/0304-4076(95)01753-4

Lagerborg, Andresa, Evi Pappa and Morten O. Ravn. (2022). "Sentimental Business Cycles". *The Review of Economic Studies,* 90(3), pp. 1358-1393. https://doi.org/10.1093/restud/rdac053

Leduc, Sylvain, and Zheng Liu. (2016). "Uncertainty shocks are aggregate demand shocks". *Journal of Monetary Economics,* 82, pp. 20-35. https://doi.org/10.1016/j.jmoneco.2016.07.002

Liu, Philip, Konstantinos Theodoridis, Haroon Mumtaz and Francesco Zanetti. (2019). "Changing macroeconomic dynamics at the zero lower bound". *Journal of Business & Economic Statistics,* 37(3), pp. 391-404. https://doi.org/10.1080/07350015.2017.1350186

Longstaff, Francis A., Jun Pan, Lasse H. Pedersen and Kenneth J. Singleton. (2011). "How sovereign is sovereign credit risk?". *American Economic Journal: Macroeconomics,* 3(2), pp. 75-103. https://doi.org/10.1257/mac.3.2.75

Ludvigson, Sydney C., Sai Ma and Serena Ng. (2019). "Uncertainty and business cycles: Exogenous impulse or endogenous response?". NBER Working Paper Series, 21803, National Bureau of Economic Research. https://doi.org/10.3386/w21803

Macera, Manuel, Albert Marcet and Juan Pablo Nicolini. (2022). "On the risk of leaving the euro". Working Papers, 760, Federal Reserve Bank of Minneapolis. https://doi.org/10.21034/wp.760

Meinen, Philipp, and Oke Roeche. (2017). "On measuring uncertainty and its impact on investment: Cross-country evidence from the euro area". *European Economic Review*, 92, pp. 161-179. https://doi.org/10.1016/j.euroecorev.2016.12.002

Merler, S., and J. Pisani-Ferry. (2012). "Who's afraid of sovereign bonds?". *Bruegel Policy Contributions*, 2012(2). https://www.bruegel.org/sites/default/files/wp_attachments/pc_2012_02_debt_.pdf

Mumtaz, Haroon, and Paolo Surico. (2018). "Policy uncertainty and aggregate fluctuations". *Journal of Applied Econometrics*, 33(3), pp. 319-331. https://doi.org/10.1002/jae.2613

Mumtaz, Haroon, and Francesco Zanetti. (2012). "Neutral technology shocks and the dynamics of labor input: Results from an agnostic identification". *International Economic Review*, 53(1), pp. 235-254. https://doi.org/10.1111/j.1468-2354.2011.00678.x

Mumtaz, Haroon, and Francesco Zanetti. (2013). "The impact of the volatility of monetary policy shocks". *Journal of Money, Credit and Banking*, 45(4), pp. 535-558. https://doi.org/10.1111/jmcb.12015

Piffer, Michele, and Maximilian Podstawski. (2018). "Identifying uncertainty shocks using the price of gold". *The Economic Journal*, 128(616), pp. 3266-3284. https://doi.org/10.1111/ecoj.12545

Ramey, Valerie A. (2011). "Identifying Government Spending Shocks: It's all in the Timing". *The Quarterly Journal of Economics*, 126(1), pp. 1-50. https://doi.org/10.1093/qje/qjq008

Ramey, Valerie A., and Matthew D. Shapiro. (1998). "Costly capital reallocation and the effects of government spending". *Carnegie-Rochester Conference Series on Public Policy*, 48, pp. 145-194. https://doi.org/10.1016/S0167-2231(98)00020-7

Redl, C. (2018). "Uncertainty matters: Evidence from close elections". Staff Working Papers, 722, Bank of England. https://doi.org/10.2139/ssrn.3167381

Ricco, Giovanni, Giovanni Callegari and Jacopo Cimadomo. (2016). "Signals from the government: Policy disagreement and the transmission of fiscal shocks". *Journal of Monetary Economics*, 82, pp. 107-118. https://doi.org/10.1016/j.jmoneco.2016.07.004

Rossi, Barbara, Tatevik Sekhposyan and Mattheiu Soupre. (2016). "Understanding the Sources of Macroeconomic Uncertainty". CEPR Discussion Papers, 11415, CEPR. https://cepr.org/system/files/publication-files/DP11415.pdf

Rotemberg, Julio J. (1982). "Sticky prices in the United States". *Journal of Political Economy*, 90(6), pp. 1187-1211. https://doi.org/10.1086/261117

Rubio-Ramírez, Juan F., Daniel Waggoner and Tao Zha. (2010). "Structural vector autoregressions: Theory of identification and algorithms for inference". *Review of Economic Studies*, 77(2), pp. 665-696. https://doi.org/10.1111/j.1467-937X.2009.00578.x

Uhlig, Harald. (2005). "What are the effects of monetary policy on output? Results from an agnostic identification procedure". *Journal of Monetary Economics*, 52(2), pp. 381-419. https://doi.org/10.1016/j.jmoneco.2004.05.007

Uribe, Martín. (2006). "A fiscal theory of sovereign risk". *Journal of Monetary Economics*, 53(8), pp. 1857-1875. https://doi.org/10.1016/j.jmoneco.2005.09.003

Uribe, Martín, and Vivian Z. Yue. (2006). "Country spreads and emerging countries: Who drives whom?". *Journal of International Economics*, 69(1), pp. 6-36. https://doi.org/10.1016/j.jinteco.2005.04.003

Supplementary Material for "Sovereign Uncertainty"

[For Online Publication]

Edgar Silgado-Gómez

A Empirical Section

A.1 Data definitions and sources

This section presents the datasets used to compute sovereign uncertainty and macro-financial uncertainty, as well as the data employed in the VAR analysis.

A.1.1 Macro-financial Dataset

Table 3: Macro-financial Series (1)

Description	Mnemonic	Transformation
IP in manufacturing	sts.m.es.y.prod.2c0000.3.000	$\Delta log(x_t)$
IP in construction (buildings)	sts.m.es.y.prod.cc1000.3.000	$\Delta log(x_t)$
IP in construction (civil engineering)	sts.m.es.y.prod.cc2000.3.000	$\Delta log(x_t)$
IP consumer goods	sts.m.es.y.prod.ns0080.3.000	$\Delta log(x_t)$
IP non-durable consumer goods	sts.m.es.y.prod.ns0070.3.000	$\Delta log(x_t)$
IP intermediate goods	sts.m.es.y.prod.ns0040.3.000	$\Delta log(x_t)$
IP investment goods	sts.m.es.y.prod.ns0050.3.000	$\Delta log(x_t)$
IP energy	sts.m.es.y.prod.ns0091.3.000	$\Delta log(x_t)$
Unemployment rate, total	sts.m.es.s.uneh.rtt000.4.000	$\Delta log(x_t)$
Unemployment rate, under 25	sts.m.es.s.uneh.ryt000.4.000	$\Delta log(x_t)$
Unemployment rate, total, male	sts.m.es.s.uneh.rtm000.4.000	$\Delta log(x_t)$
Unemployment rate, total, female	sts.m.es.s.uneh.rtf000.4.000	$\Delta log(x_t)$
Producer price inflation:		
- Manufacturing	sts.m.es.n.prin.2c0000.3.000	$\Delta log(x_t)$
- Total industry, excl. construction	sts.m.es.n.prin.ns0020.3.000	$\Delta log(x_t)$
- Intermediate goods	sts.m.es.n.prin.ns0040.3.000	$\Delta log(x_t)$
- Capital goods	sts.m.es.n.prin.ns0050.4.000	$\Delta log(x_t)$
- Durable consumer goods	sts.m.es.n.prin.ns0060.4.000	$\Delta log(x_t)$
- Consumer goods	sts.m.es.n.prin.ns0080.4.000	$\Delta log(x_t)$
Indicator of negotiated wages	sts.m.es.n.inwr.000000.5.anr	$\Delta log(x_t)$
Harmonised competitiveness indicator	exr.m.e8.esp.nn00.a	$\Delta log(x_t)$

Note: When required, non-seasonally adjusted series are seasonally adjusted using US Census Bureau's X-12 ARIMA.

Table 4: Macro-financial Series (2)

Description	Mnemonic	Transformation
World market price of raw materials:		
- Total excl. energy	n023phwx@eudata	$\Delta log(x_t)$
- Energy	n023phwe@eudata	$\Delta log(x_t)$
- Coal	pecau@wbprices	$\Delta log(x_t)$
- Crude oil	peobr@wbprices	$\Delta log(x_t)$
Securities:		
- Total	sec.m.es.1000.f33000.n.1.z01.e.z	$\Delta log(x_t)$
- MFIs	sec.m.es.12a0.f33000.n.1.z01.e.z	$\Delta log(x_t)$
- OFIs	sec.m.es.1235.f33000.n.1.z01.e.z	$\Delta log(x_t)$
- NFC	sec.m.es.1100.f33000.n.1.z01.e.z	$\Delta log(x_t)$
Shares:		
- Total	sec.m.es.1000.f51100.m.1.eur.e.z	$\Delta log(x_t)$
- MFIs	sec.m.es.1220.f51100.m.1.eur.e.z	$\Delta log(x_t)$
- Non-MFI corporations	sec.m.es.1610.f51100.m.1.eur.e.z	$\Delta log(x_t)$
- NFC	sec.m.es.1100.f51100.m.1.eur.e.z	$\Delta log(x_t)$
- OFIs	sec.m.es.1235.f51100.m.1.eur.e.z	$\Delta log(x_t)$
- OFIs excl. pension funds	sec.m.es.1230.f51100.m.1.eur.e.z	$\Delta log(x_t)$
Industrial survey:		
- Production trend over recent months	sur.m.es.s.ecfin.man001.tt	Δx_t
- Assessment of order-book levels	sur.m.es.s.ecfin.man002.tt	Δx_t
- Assessment of export order-book levels	sur.m.es.s.ecfin.man003.tt	Δx_t
- Assessment of stocks of finished products	sur.m.es.s.ecfin.man004.tt	Δx_t
- Production expectations	sur.m.es.s.ecfin.man005.tt	Δx_t
- Price expectations	sur.m.es.s.ecfin.man006.tt	Δx_t
- Employment expectations	sur.m.es.s.ecfin.man007.tt	Δx_t
- Industrial confidence indicator	sur.m.es.s.ecfin.man099.tt	Δx_t
Consumer survey:		
- Consumer confidence	sur.m.es.s.ecfin.cns099.tt	Δx_t
- Financial situation	sur.m.es.s.ecfin.cns001.tt	Δx_t
- Financial expectations	sur.m.es.s.ecfin.cns002.tt	Δx_t
- Economic situation	sur.m.es.s.ecfin.cns003.tt	Δx_t
- Economic expectations	sur.m.es.s.ecfin.cns004.tt	Δx_t
- Past inflation	sur.m.es.s.ecfin.cns005.tt	Δx_t
- Expected inflation	sur.m.es.s.ecfin.cns006.tt	Δx_t
- Unemployment expectations	sur.m.es.s.ecfin.cns007.tt	Δx_t
- Past major purchases	sur.m.es.s.ecfin.cns008.tt	Δx_t
- Expected major purchases	sur.m.es.s.ecfin.cns009.tt	Δx_t
- Expected savings	sur.m.es.s.ecfin.cns011.tt	Δx_t
- Financial situation of household	sur.m.es.s.ecfin.cns012.tt	Δx_t
Construction survey:		
- Trend of activity	sur.m.es.s.ecfin.con001.tt	Δx_t
- Limits to production - none	sur.m.es.s.ecfin.con02a.tt	Δx_t
- Limits to production - insufficient demand	sur.m.es.s.ecfin.con02b.tt	Δx_t
- Limits to production - weather conditions	sur.m.es.s.ecfin.con02c.tt	Δx_t
- Limits to production - shortage lab. force	sur.m.es.s.ecfin.con02d.tt	Δx_t
- Limits to production - other factors	sur.m.es.s.ecfin.con02f.tt	Δx_t
- Limits to production - fin. constraints	sur.m.es.s.ecfin.con02g.tt	Δx_t
- Assessment of order books	sur.m.es.s.ecfin.con003.tt	Δx_t
- Employment expectations	sur.m.es.s.ecfin.con004.tt	Δx_t
- Price expectations	sur.m.es.s.ecfin.con005.tt	Δx_t
- Confidence	sur.m.es.s.ecfin.con099.tt.tt	Δx_t

Note: When required, non-seasonally adjusted series are seasonally adjusted using US Census Bureau's X-12 ARIMA.

Table 5: Macro-financial Series (3)

Description	Mnemonic	Transformation
Retail trade survey:		
- Present business situation	sur.m.es.s.ecfin.ret001.tt	Δx_t
- Assessment of stocks	sur.m.es.s.ecfin.ret002.tt	Δx_t
- Orders placed with suppliers	sur.m.es.s.ecfin.ret003.tt	Δx_t
- Expected business situation	sur.m.es.s.ecfin.ret004.tt	Δx_t
- Employment expectation	sur.m.es.s.ecfin.ret005.tt	Δx_t
- Business confidence	sur.m.es.s.ecfin.ret099.tt	Δx_t
Real exports of goods	esnixc@spain	$\Delta log(x_t)$
Real imports of goods	esnimc@spain	$\Delta log(x_t)$
Export prices	esnpfx@spain	$\Delta log(x_t)$
Import prices	esnpfm@spain	$\Delta log(x_t)$
Terms of trade	esnpfx@spain/esnpfm@spain	x_t
Global trade (volume)	s001iqxm@g10	$\Delta log(x_t)$
Global trade (unit)	s001iuxm@g10	$\Delta log(x_t)$
Global export prices	s001iux@g10	$\Delta log(x_t)$
Global import prices	s001ium@g10	$\Delta log(x_t)$
Export competitiveness	esnpfx@spain/s001iux@g10	x_t
Consumer Price Index	icp.m.es.n.000000.4.inx	$\Delta log(x_t)$
Total bank lending	esnfcitr@spain	$\Delta log(x_t)$
Car registrations - passenger cars	sts.m.es.y.creg.pc0000.3.abs	$\Delta log(x_t)$
Stock Market Index	www.bolsasymercados.es	$\Delta log(x_t)$
Nominal Effective Exchange Rate	x184dnn@intwkly	x_t
3-Months interbank rate	ir3tib01esm156n	x_t

Note: When required, non-seasonally adjusted series are seasonally adjusted using US Census Bureau's X-12 ARIMA.

A.1.2 Government Finances Dataset

Table 6: Government Series

Description	Mnemonic	Transformation
Taxes under common regime	esnfeta@spain	$\Delta log(x_t)$
Revenue cash basis deficit state resources and uses according to the national accounts:		
- Revenues	esnfprev@spain	$\Delta log(x_t)$
- Expenditures	esnfpexp@spain	$\Delta log(x_t)$
Marketable state debt	esnfdh@spain	$\Delta log(x_t)$
Treasury bills	esnfdb@spain	$\Delta log(x_t)$
Unstripped bonds	esnfdhu@spain	$\Delta log(x_t)$
Regional government bonds	esnfdob@spain	$\Delta log(x_t)$
Treasury bills outstanding by holder:		
- MFIs excluding money market funds	esofdbb@spain	$\Delta log(x_t)$
- Money market funds and other FIs	esofdfb@spain	$\Delta log(x_t)$
- Nonfinancial corporations	esofdcb@spain	$\Delta log(x_t)$
- Households and NPISHs	esofdhb@spain	$\Delta log(x_t)$
- Rest of the world	esofdab@spain	$\Delta log(x_t)$
Unstripped bonds and stripped principal by holder:		
- MFIs excluding money market funds	esofdbfd@spain	$\Delta log(x_t)$
- Money market funds and other FIs	esofdbod@spain	$\Delta log(x_t)$
- Nonfinancial corporations	esofdbnd@spain	$\Delta log(x_t)$
- Households and NPISHs	esofdhb@spain	$\Delta log(x_t)$
- Rest of the world	esofdbwd@spain	$\Delta log(x_t)$
General government debt at different maturities:		
- Short term debt	esmf1gss@spain	$\Delta log(x_t)$
- Long term debt	esmf1gsl@spain	$\Delta log(x_t)$
- Short term loans	esmf1gls@spain	$\Delta log(x_t)$
- Long term loans	esmf1gll@spain	$\Delta log(x_t)$
Interest rates on government bonds at different maturities:		
- 1 year interest rate	gves03(cm01)	x_t
- 5 years interest rate	gves03(cm05)	x_t
- 10 years interest rate	gves03(cm10)	x_t
FTSE WGBI 1-3 years: bond return index	esmf1gss@spain	$\Delta log(x_t)$
FTSE WGBI +5 years: bond return index	esmf1gss@spain	$\Delta log(x_t)$
FTSE WGBI +10 years: bond return index	esmf1gss@spain	$\Delta log(x_t)$
FTSE WGBI all maturities: bond return index	esmf1gss@spain	$\Delta log(x_t)$
FTSE WGBI +5 years: debt market value	esmf1gss@spain	$\Delta log(x_t)$
FTSE WGBI +10 years: debt market value	esmf1gss@spain	$\Delta log(x_t)$
FTSE WGBI all maturities: debt market value	esmf1gss@spain	$\Delta log(x_t)$

Note: When required, non-seasonally adjusted series are seasonally adjusted using US Census Bureau's X-12 ARIMA.

A.1.3 VAR Data

The following monthly variables are used in the BVAR and T-BVAR exercises. The sample is from May 1997 to December 2019. The starting and ending dates are dictated by the availability of the sovereign uncertainty measure and the presence of the COVID-19 pandemic:

- *Industrial Production* is production of total industry (seasonally adjusted), obtained from the OECD (retrieved from FRED). Mnemonic: ESPPROINDMISMEI.

- *Unemployment* is total harmonized unemployment rate (seasonally adjusted), obtained from the OECD (retrieved from FRED). Mnemonic: LRHUTTTTESM156S.
- *Price Level* is the non-seasonally adjusted consumer price index (all items), obtained from the OECD (retrieved from FRED). It is seasonally adjusted using US Census Bureau's X-12 ARIMA. Mnemonic: ESPCPIALLMINMEI.
- *Bank loans* is nominal non-seasonally adjusted bank lending to NFIs, obtained from Datastream. Mnemonic: ESBANKLPA. It is seasonally adjusted using US Census Bureau's X-12 ARIMA. It is also divided by CPI to express it in real terms.
- *Long-term rate* is defined as the return on the 10-years Spanish government bonds, obtained from Datastream. Mnemonic: GVES03(CM10).
- *Government Debt* is central government marketable debt, obtained from Haver Analytics. It is seasonally adjusted using US Census Bureau's X-12 ARIMA. Mnemonic: ESNFD@SPAIN.
- *Stock Market* is the IBEX-35 market index extracted from `www.bolsasymercados.es`.
- *Confidence* is overall consumer and industrial sentiments, obtained from the Statistical Data Warehouse (ECB). Mnemonic: for consumer, sur.m.es.s.ecfin.cns099.tt and for industrial, sur.m.es.s.ecfin.man099.tt.
- *Sovereign and Macro-financial Uncertainties* are computed as explained in section 2.

For the matching estimation of the DSGE model, the following variables are employed in the quarterly VAR:

- *Output* is seasonally adjusted real GDP, obtained from Haver Analytics. Mnemonic: S184NGPC@G10.
- *Consumption* is seasonally adjusted real personal consumption expenditures, obtained from Haver Analytics. Mnemonic: S184NCPC@G10.
- *Investment* is seasonally adjusted real gross fixed capital formation, obtained from Haver Analytics. Mnemonic: S184NFC@G10.
- *Hours Worked* is seasonally adjusted total hours worked (employment), obtained from the SDW (ECB). Mnemonic: mna.q.y.es.w2.s1.s1z.emp.z.t.z.hw.z.n.
- *Price Inflation* is year-on-year growth rate of the seasonally adjusted GDP implicit price deflator, obtained from Haver Analytics. Mnemonic: S184NGPJ@G10.
- The successive variables, which are also included in the quarterly VAR, are just the quarterly aggregation of the previous monthly series: *stock market index, government debt, long-term interest rate on government bonds, bank loans, confidence, macro-financial uncertainty and sovereign uncertainty.*

A.1.4 Additional Data

Finally, some extra variables from which their respective business cycle statistics are extracted for Table 2:

- *Nominal Interest Rate* is the 3-months money market interest rate (EA11-19, AVG), obtained from Haver Analytics. Mnemonic: I023M@EUDATA.

- *Credit Spread* is the credit risk indicator for non-financial corporations in Spain, obtained from Gilchrist and Mojon (2018).
- *Bond spread* is defined as return on one year Spanish government bonds net return on one year German government bonds, obtained from Datastream. Mnemonic: GVES03(CM01) for Spain and GVBD03(CM01) for Germany.

A.2 Substituting Bond Rates for Spreads and the Comparison with 12-months ahead Sovereign Uncertainty

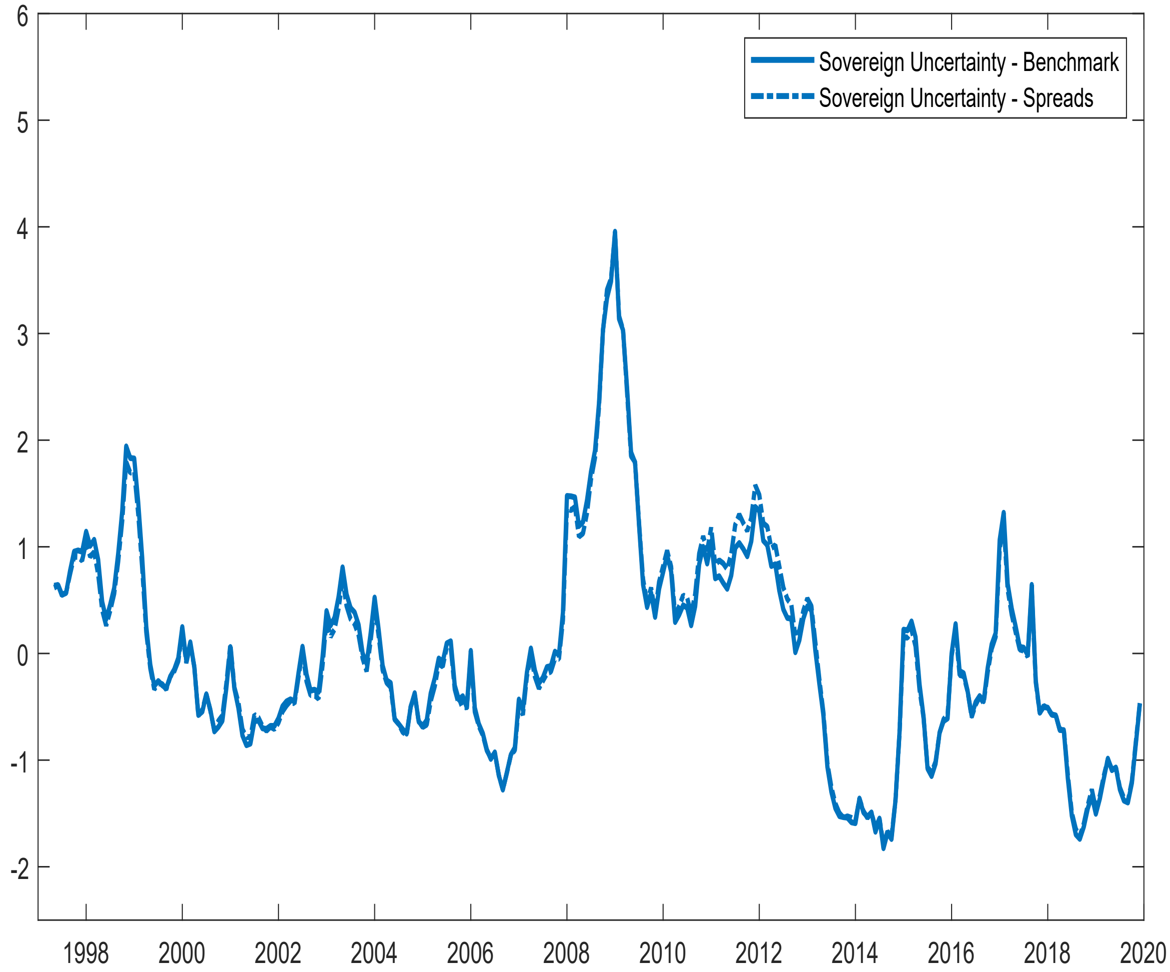

Figure 11: Sovereign Uncertainty: Substituting Bond Rates for Spreads in the Government Finances Dataset

Note: The solid line represents the benchmark SU index; the dash-dot line exhibits the SU indicator when substituting government bond rates at different maturities for their spreads (with respect to Germany) in the government finances dataset. Both measures are standardized.

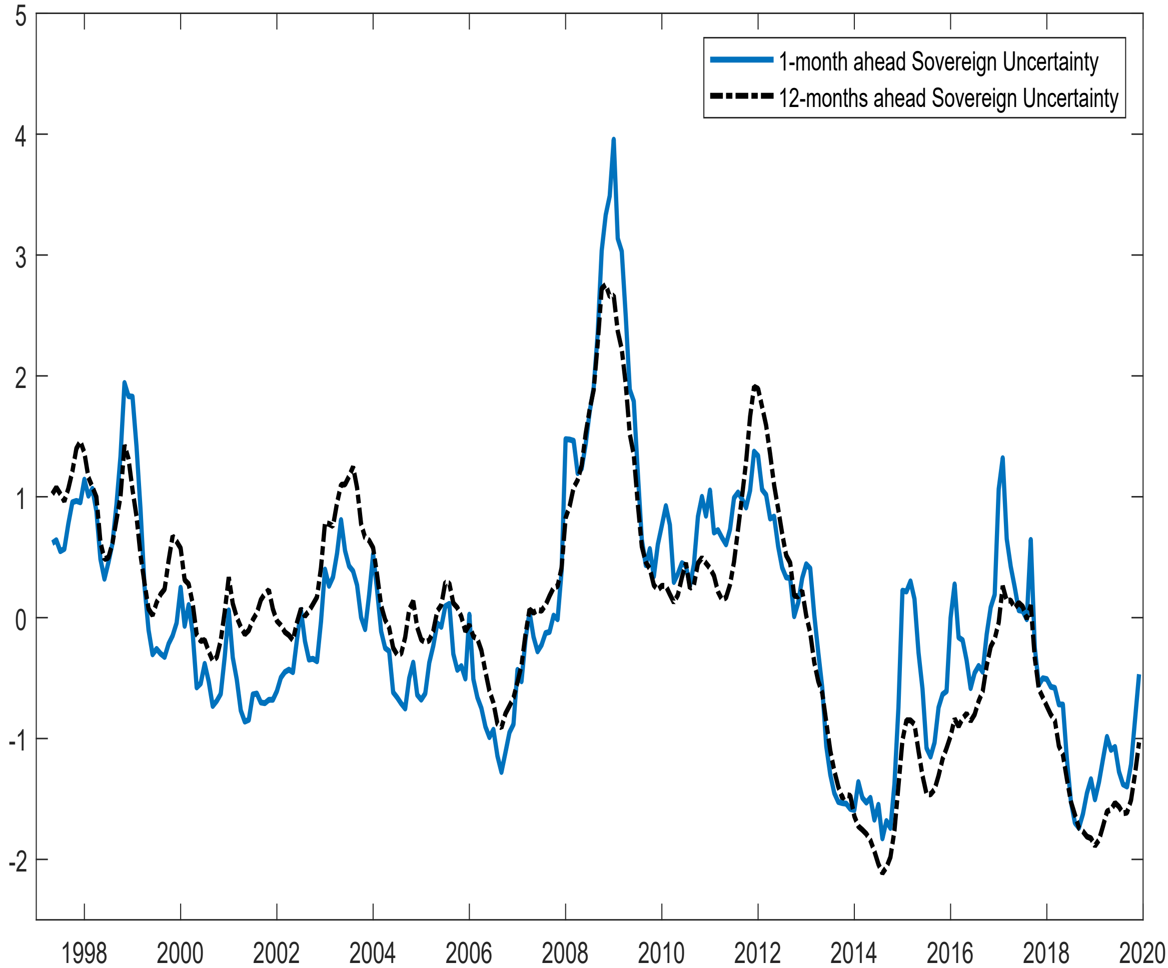

Figure 12: Sovereign Uncertainty at Different Forecast Horizons

Note: The solid-blue and dash-dot-black lines indicate the estimated 1-month and 12-months ahead sovereign uncertainty, respectively. Both measures are standardized.

A.3 Decomposition of SU: Prices vs. Quantities

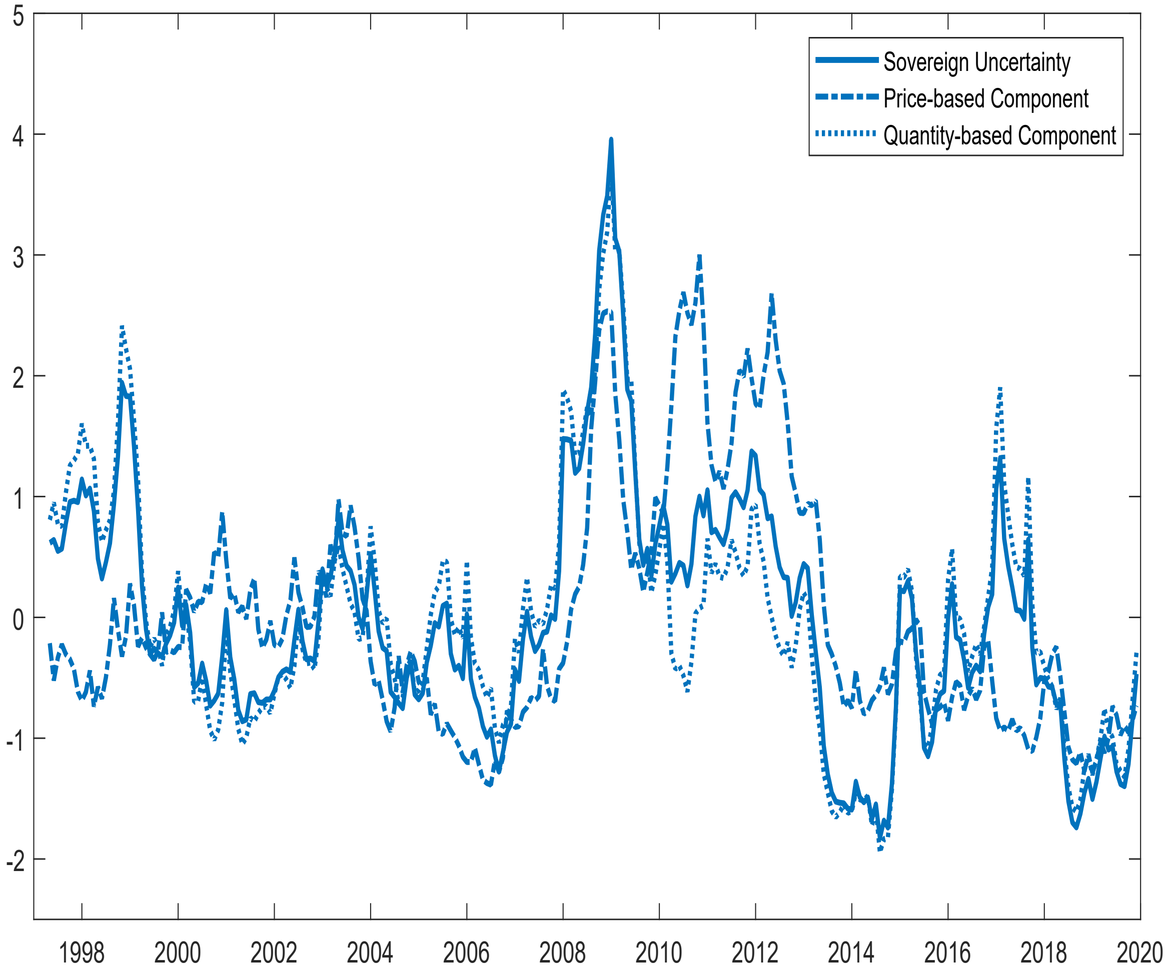

Figure 13: Sovereign Uncertainty: Prices vs. Quantities

Note: The solid line indicates the estimated sovereign uncertainty; the dash-dot line represents the price-based component of sovereign uncertainty; and the dotted line exhibits the quantity-based component of sovereign uncertainty. All measures are standardized.

A.4 Comparison with EPU from Ghirelli et al. (2019)

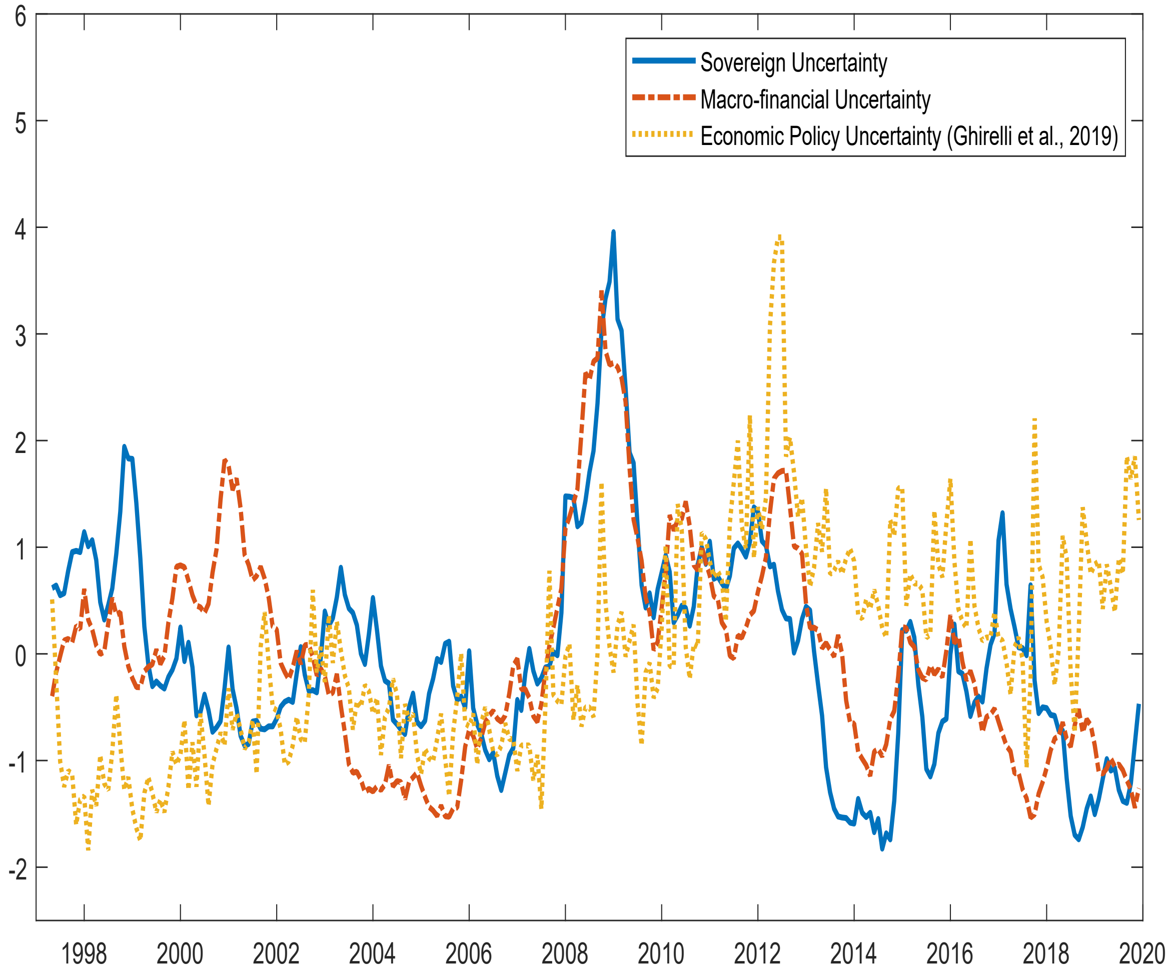

Figure 14: Sovereign Uncertainty, Macro-financial Uncertainty, and EPU

Note: The solid-blue line indicates the estimated sovereign uncertainty; the dash-dot-orange line represents the aggregate macro-financial uncertainty; and the dotted-yellow line exhibits the economic policy uncertainty index from Ghirelli et al. (2019). All measures are standardized.

A.5 VAR Robustness Checks and Additional Results

This section presents the complete figures of the robustness checks under both identification strategies employed in the paper: recursive schemes (A.5.1) and a combination of sign, event-based and ratio restrictions (A.5.2). It also documents the relevance of the data-rich approach (A.5.3), the contribution of sovereign uncertainty shocks by performing a forecast error variance decomposition exercise (A.5.4), a historical decomposition analysis to see how important any of the uncertainty indicators are in historical period (A.5.5) and the series of estimated shocks under both identification techniques (A.5.6).

A.5.1 Recursive Identification

Figure 15: IRFs to One Standard Deviation Shock to Sovereign Uncertainty: Including the Spread

Note: Each entry shows the median and the 68% credible bands. All responses are in monthly percent deviations from trend, except for the unemployment rate and the spread, which are expressed in monthly percentage points and annualized basis points (ABP), respectively.

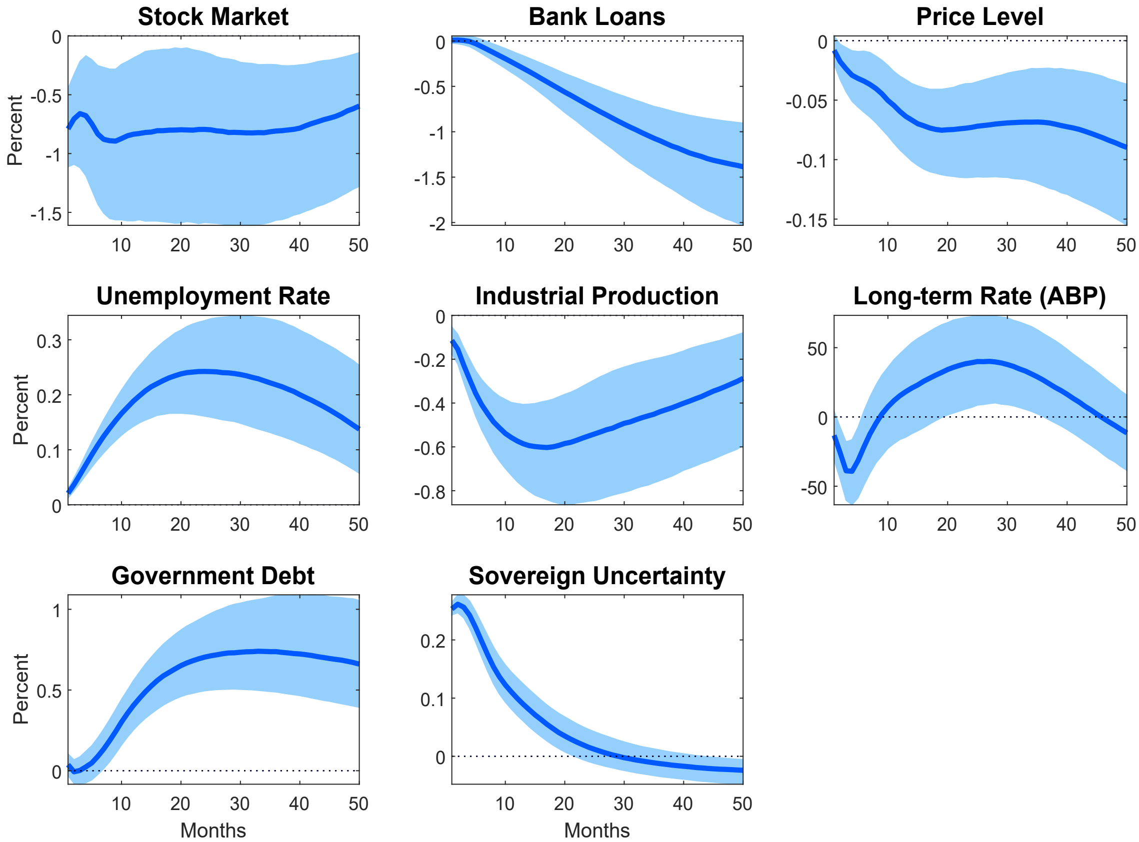

Figure 16: IRFs to One Standard Deviation Shock to Sovereign Uncertainty: SU Ordered First

Note: Each entry shows the median and the 68% credible bands. All responses are in monthly percent deviations from trend, except for the unemployment rate and the long-term rate, which are expressed in monthly percentage points and annualized basis points (ABP), respectively.

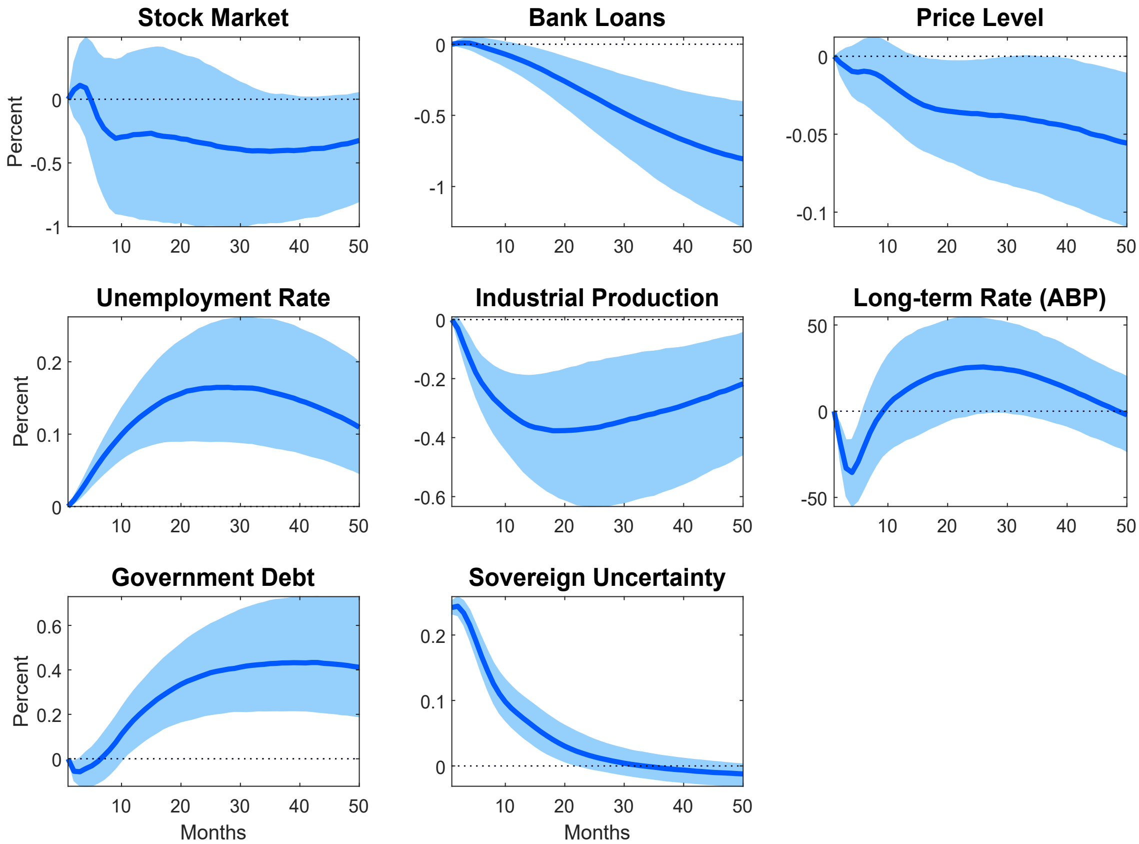

Figure 17: IRFs to One Standard Deviation Shock to Sovereign Uncertainty: Controlling for Macro-financial Uncertainty

Note: Each entry shows the median and the 68% credible bands. All responses are in monthly percent deviations from trend, except for the unemployment rate and the long-term rate, which are expressed in monthly percentage points and annualized basis points (ABP), respectively.

Figure 18: IRFs to One Standard Deviation Shock to Sovereign Uncertainty: Controlling for Consumer Confidence

Note: Each entry shows the median and the 68% credible bands. All responses are in monthly percent deviations from trend, except for the unemployment rate and the long-term rate, which are expressed in monthly percentage points and annualized basis points (ABP), respectively.

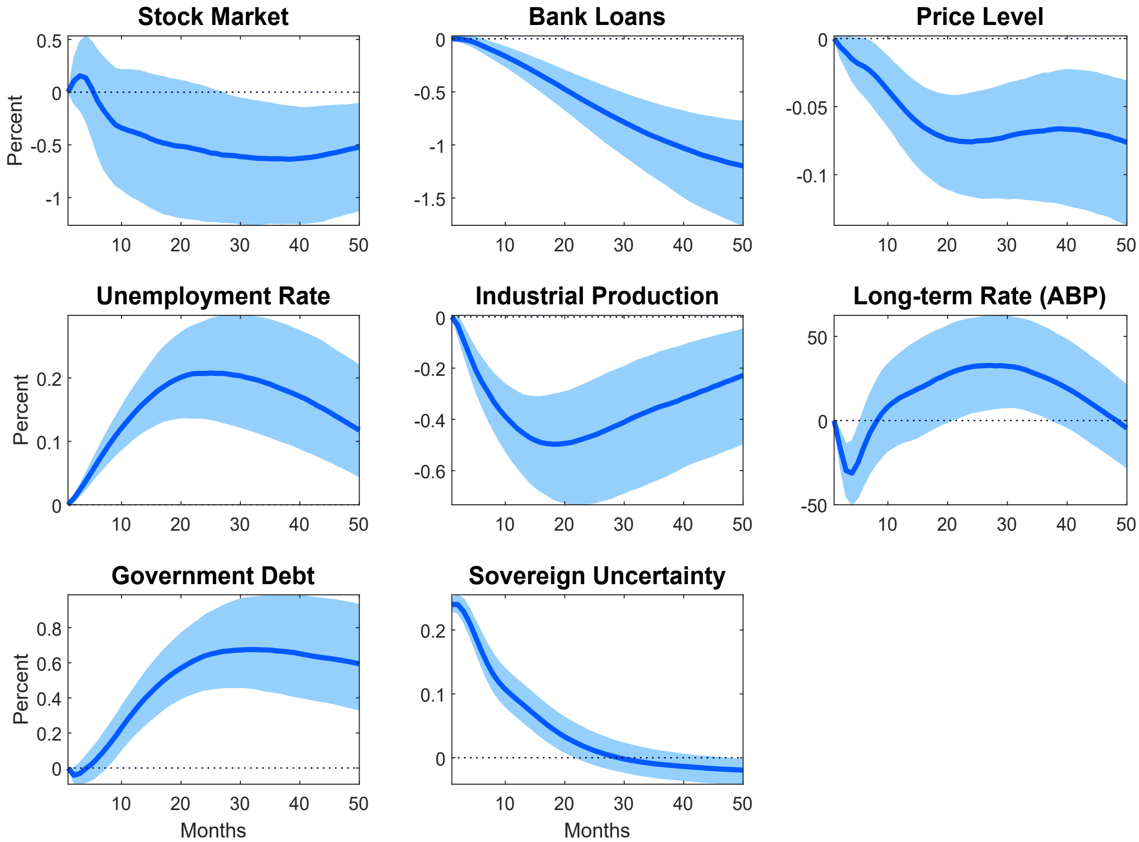

Figure 19: IRFs to One Standard Deviation Shock to Sovereign Uncertainty: Controlling for Industrial Confidence

Note: Each entry shows the median and the 68% credible bands. All responses are in monthly percent deviations from trend, except for the unemployment rate and the long-term rate, which are expressed in monthly percentage points and annualized basis points (ABP), respectively.

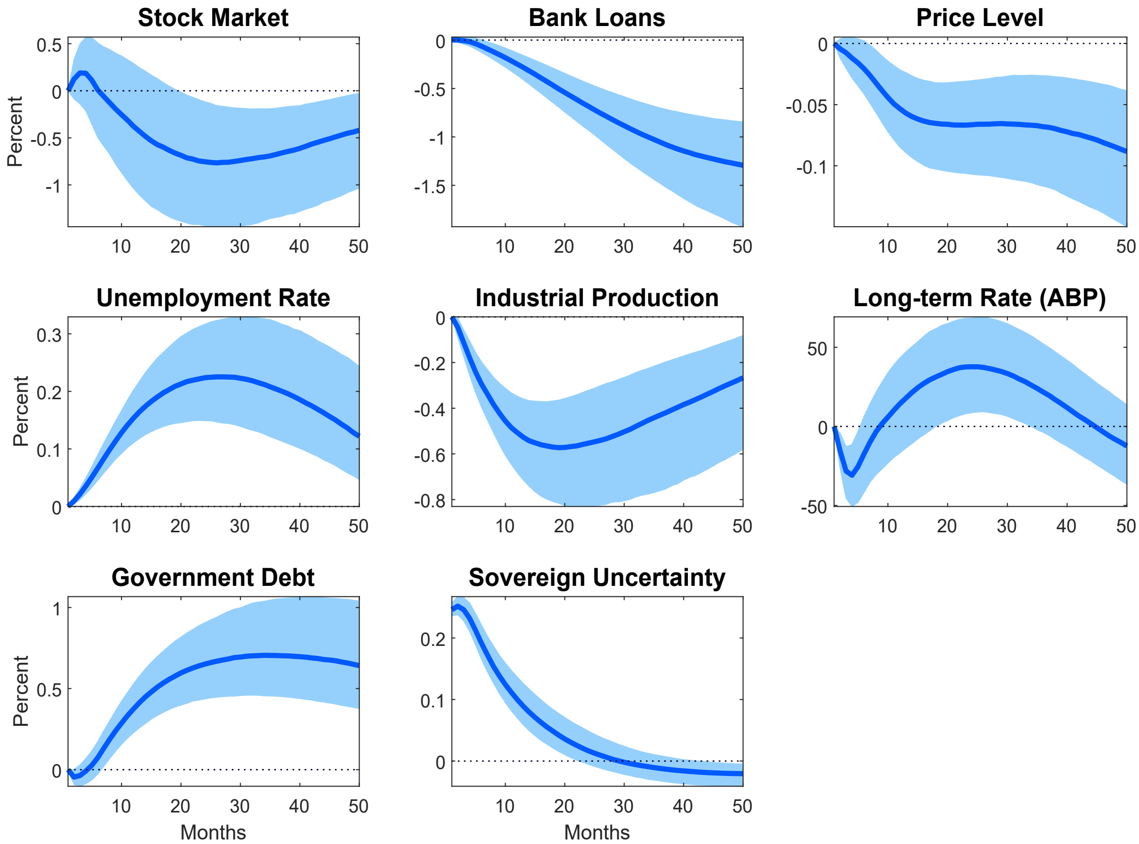

Figure 20: IRFs to One Standard Deviation Shock to Sovereign Uncertainty: VAR with 6 Lags

Note: Each entry shows the median and the 68% credible bands. All responses are in monthly percent deviations from trend, except for the unemployment rate and the long-term rate, which are expressed in monthly percentage points and annualized basis points (ABP), respectively.

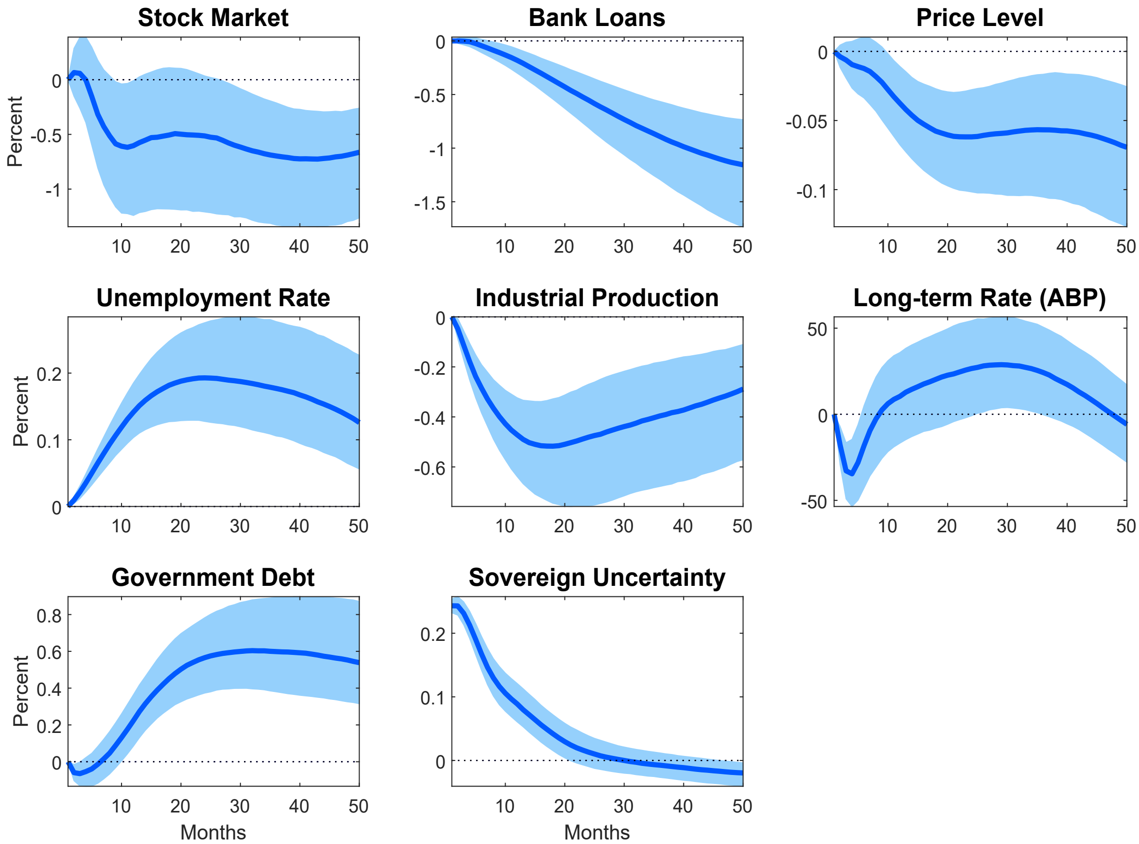

Figure 21: IRFs to One Standard Deviation Shock to Sovereign Uncertainty: VAR with 12 Lags

Note: Each entry shows the median and the 68% credible bands. All responses are in monthly percent deviations from trend, except for the unemployment rate and the long-term rate, which are expressed in monthly percentage points and annualized basis points (ABP), respectively.

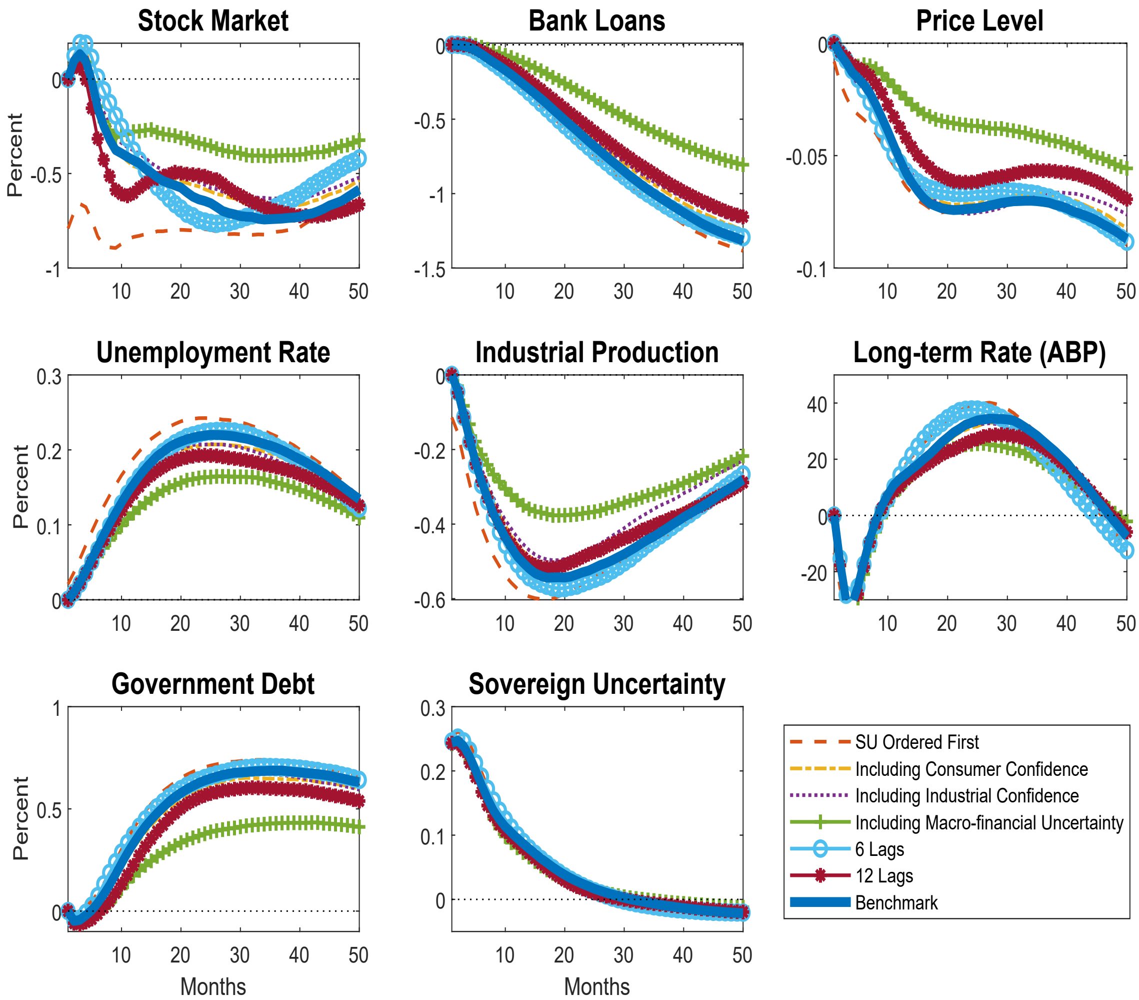

Figure 22: IRFs to One Standard Deviation Shock to Sovereign Uncertainty: All Recursive Robustness Checks

Note: Each entry shows the median responses (see Appendix A.5.1 for the complete set of IRFs with their respective credible bands). All responses are in monthly percent deviations from trend, except for the unemployment rate and the long-term rate, which are expressed in monthly percentage points and annualized basis points (ABP), respectively.

A.5.2 Sign, Event-based and Ratio Restrictions

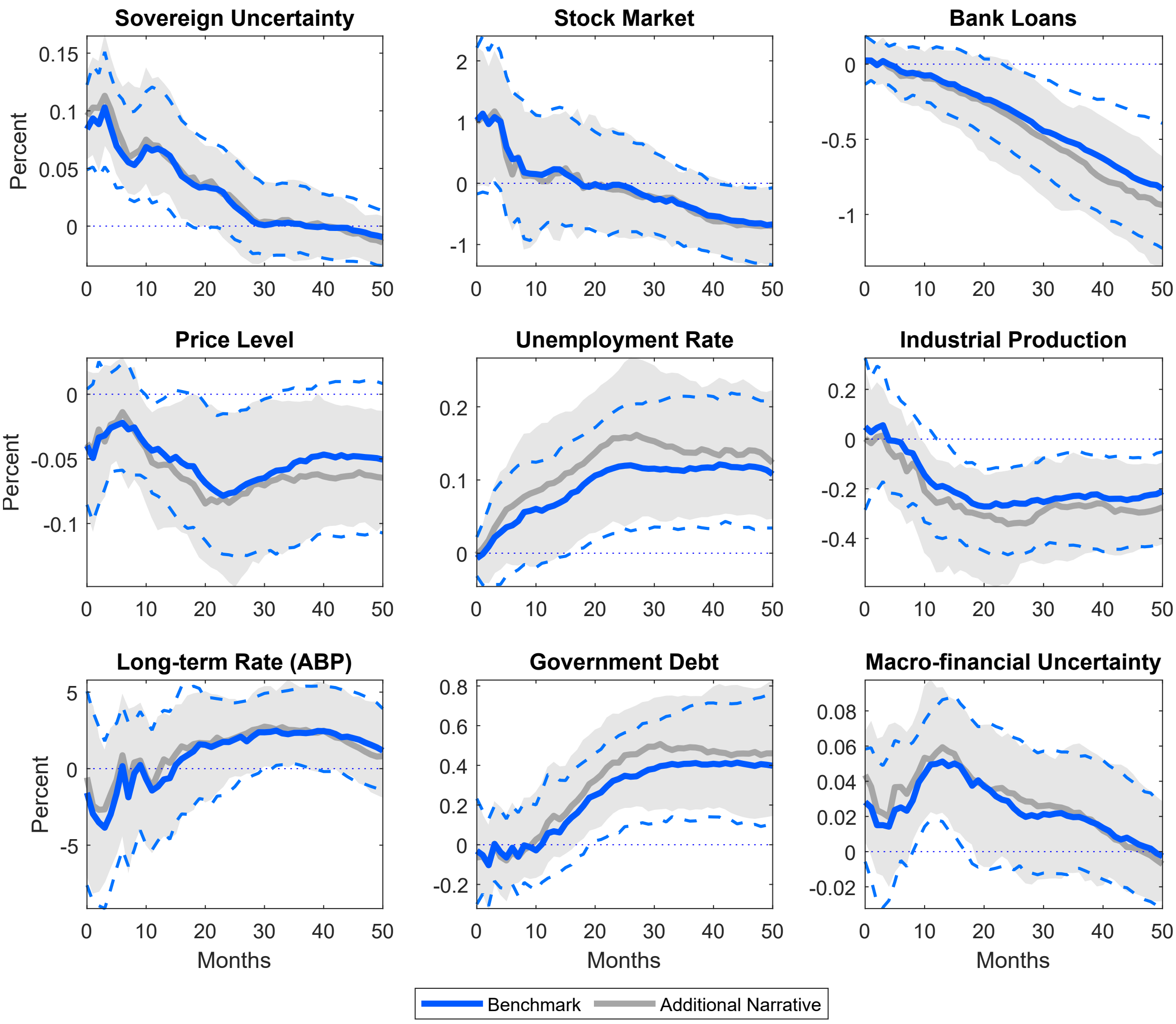

Figure 23: IRFs to One Standard Deviation Shock to Sovereign Uncertainty: Baseline Identification and the Additional Constraint

Note: Each entry shows the median and the 68% credible bands. All responses are in monthly percent deviations from trend, except for the unemployment rate and the long-term rate, which are expressed in monthly percentage points and annualized basis points (ABP), respectively. The blue line displays the results under the baseline identification with sign, event-based and ratio restrictions. The gray line exhibits the responses under the additional narrative: The MU shock is the most important contributor to the unexpected changes observed in the MU index following the Lehman Brothers' Collapse (September-October 2008).

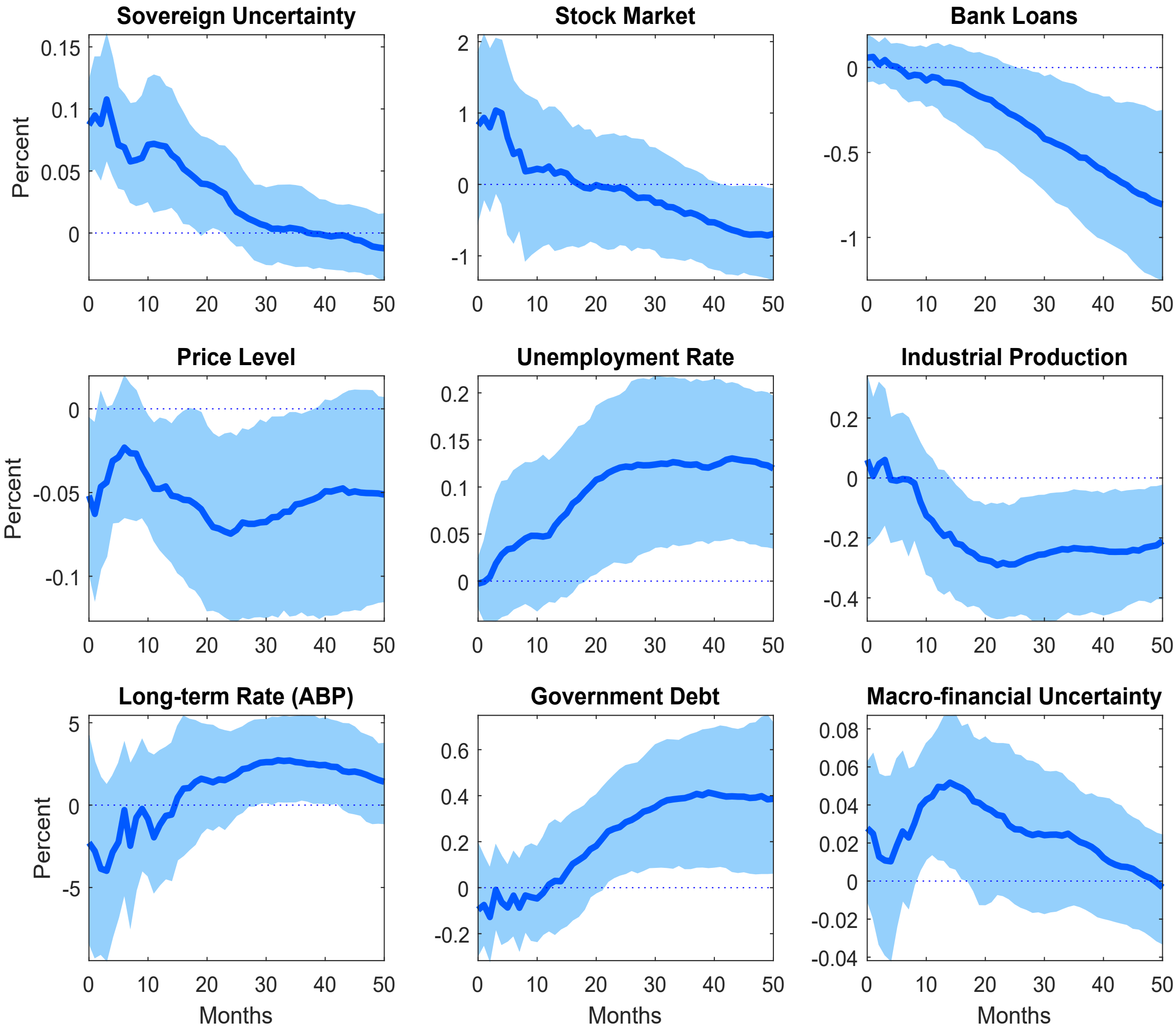

Figure 24: IRFs to One Standard Deviation Shock to Sovereign Uncertainty. Identification with Sign, Event-based and Ratio Restrictions: Adding the Bailout of Bankia

Note: Each entry shows the median and the 68% credible bands. All responses are in monthly percent deviations from trend, except for the unemployment rate and the long-term rate, which are expressed in monthly percentage points and annualized basis points (ABP), respectively.

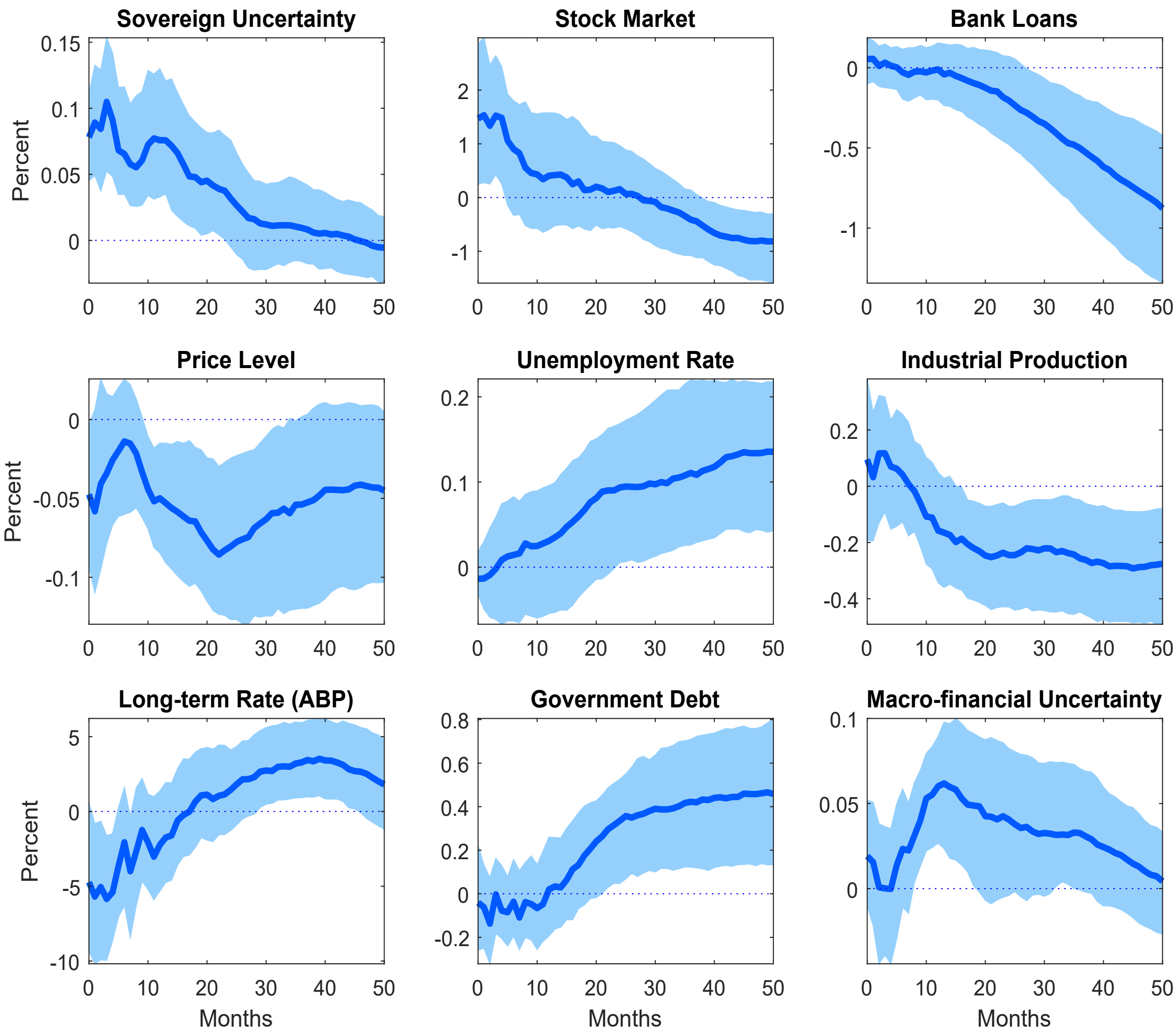

Figure 25: IRFs to One Standard Deviation Shock to Sovereign Uncertainty. Identification with Sign, Event-based and Ratio Restrictions: Adding the Announcement of Austerity Measures in July 2012

Note: Each entry shows the median and the 68% credible bands. All responses are in monthly percent deviations from trend, except for the unemployment rate and the long-term rate, which are expressed in monthly percentage points and annualized basis points (ABP), respectively.

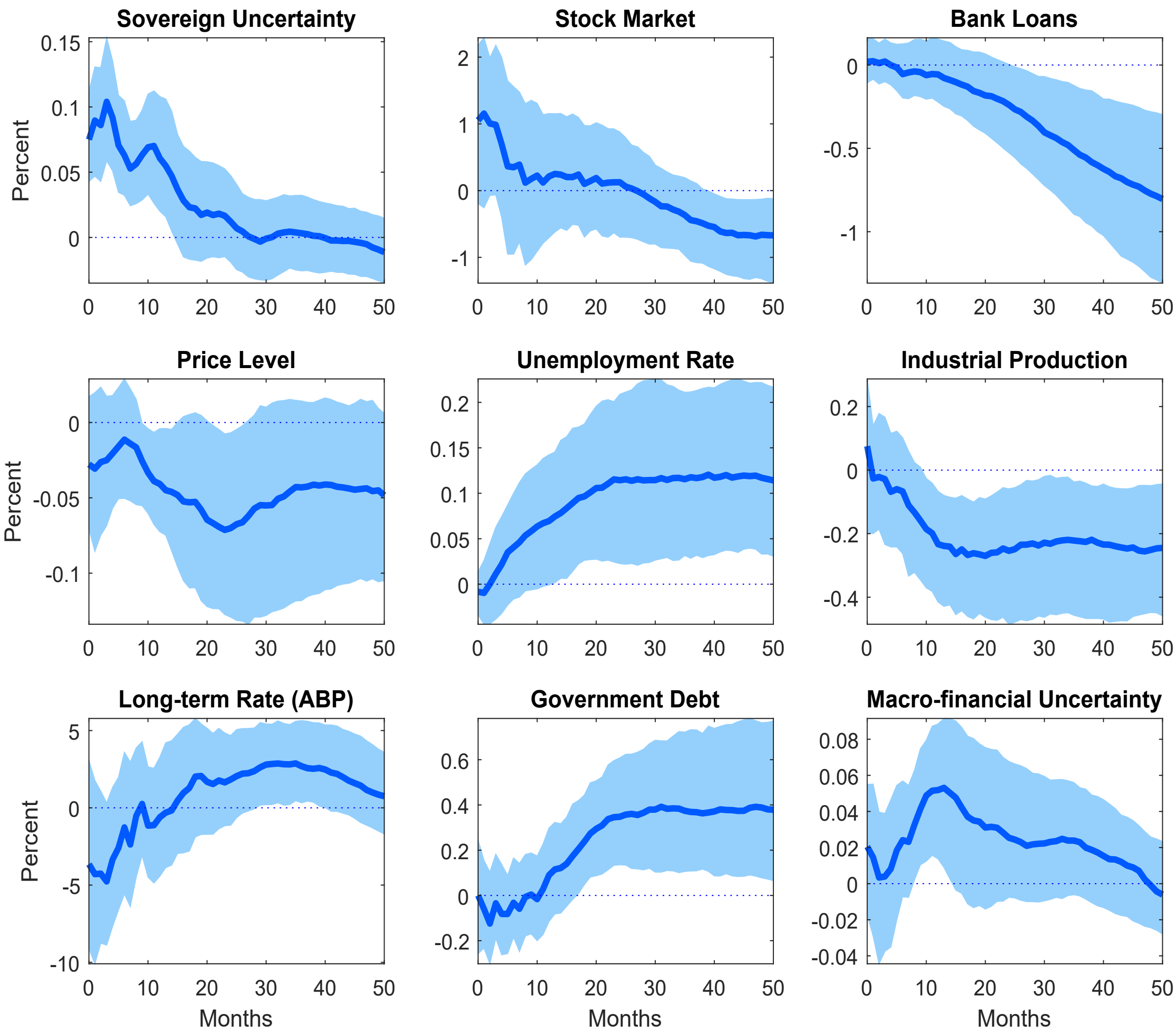

Figure 26: IRFs to One Standard Deviation Shock to Sovereign Uncertainty. Identification with Sign, Event-based and Ratio Restrictions: Controlling for Industrial Confidence

Note: Each entry shows the median and the 68% credible bands. All responses are in monthly percent deviations from trend, except for the unemployment rate and the long-term rate, which are expressed in monthly percentage points and annualized basis points (ABP), respectively.

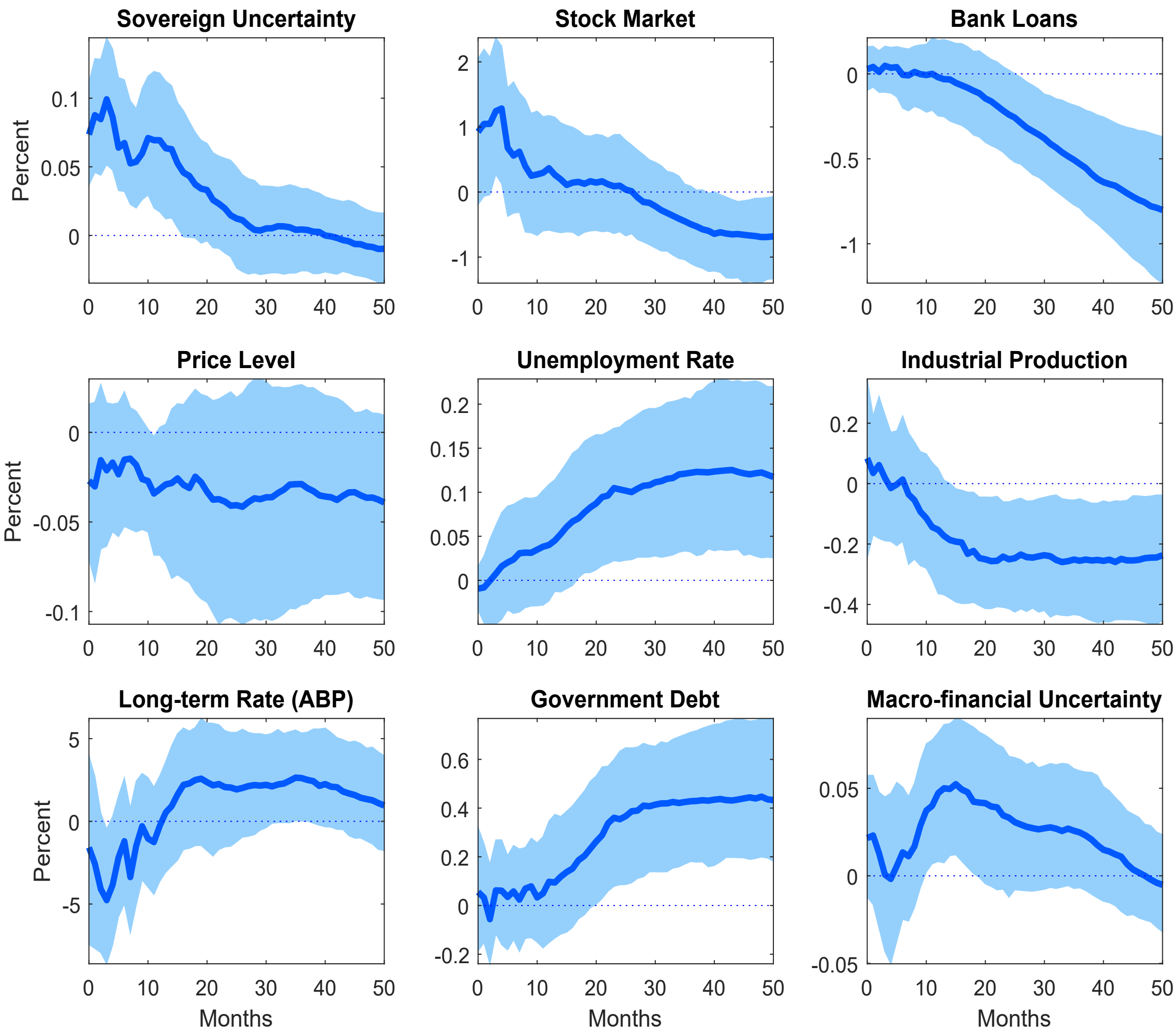

Figure 27: IRFs to One Standard Deviation Shock to Sovereign Uncertainty. Identification with Sign, Event-based and Ratio Restrictions: Controlling for GEPU

Note: Each entry shows the median and the 68% credible bands. All responses are in monthly percent deviations from trend, except for the unemployment rate and the long-term rate, which are expressed in monthly percentage points and annualized basis points (ABP), respectively.

A.5.3 Relevance of the Data-rich Approach

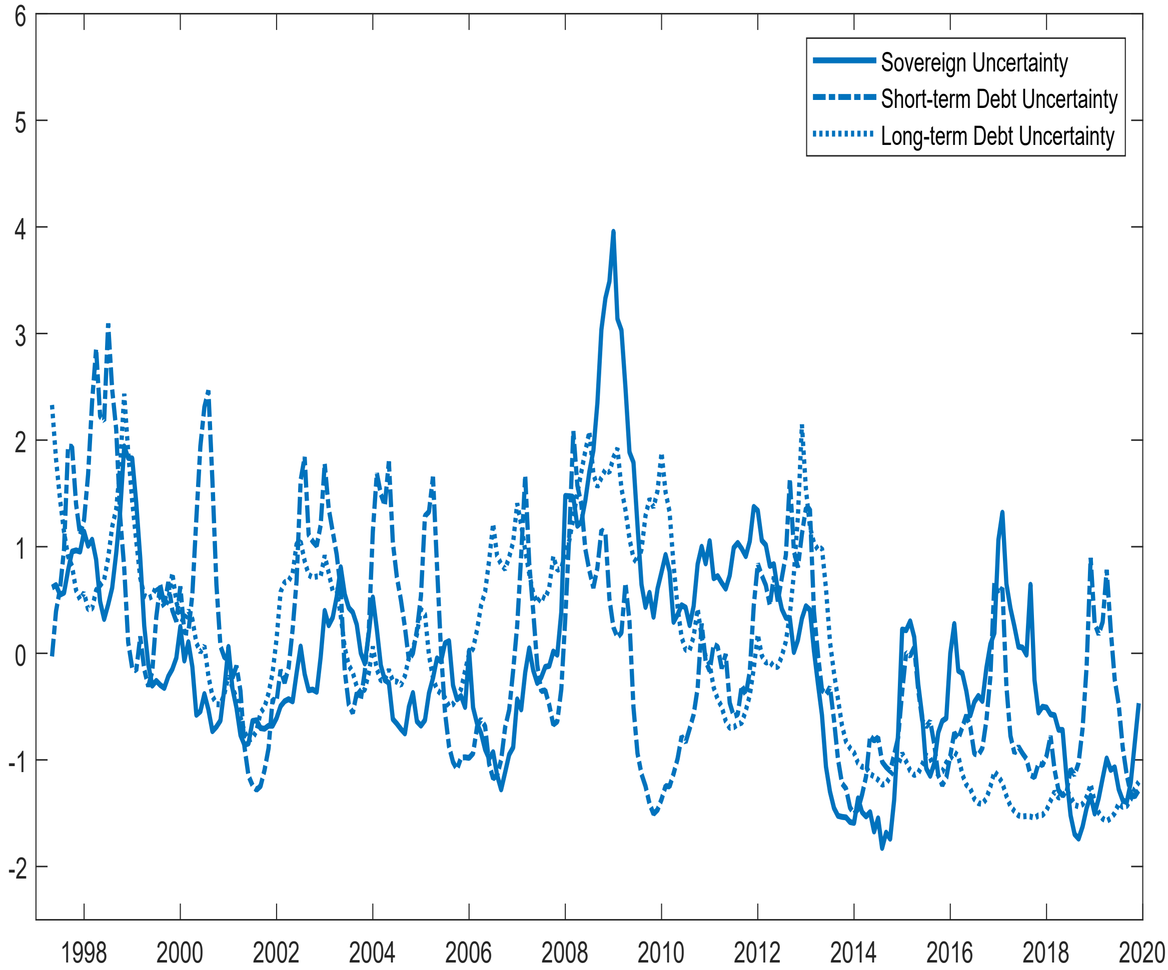

Figure 28: Sovereign Uncertainty, Short-term Debt Uncertainty, and Long-term Debt Uncertainty

Note: The solid line indicates the estimated sovereign uncertainty; the dash-dot line represents the short-term debt uncertainty; and the dotted line exhibits the long-term debt uncertainty. All measures are standardized.

Figure 29: IRFs to One Standard Deviation Shock to Short-term Debt Uncertainty

Note: Each entry shows the median and the 68% credible bands under the baseline recursive identification scheme. All responses are in monthly percent deviations from trend, except for the unemployment rate and the long-term rate, which are expressed in monthly percentage points and annualized basis points (ABP), respectively.

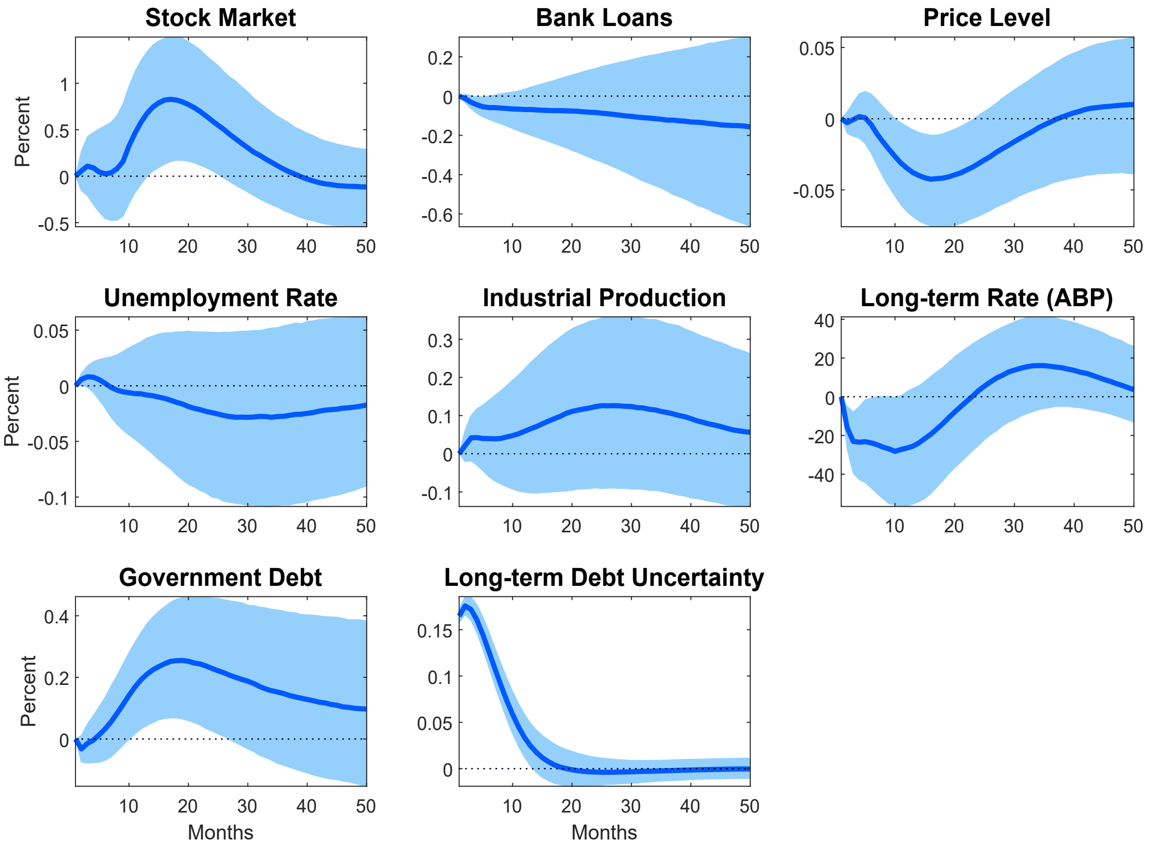

Figure 30: IRFs to One Standard Deviation Shock to Long-term Debt Uncertainty

Note: Each entry shows the median and the 68% credible bands under the baseline recursive identification scheme. All responses are in monthly percent deviations from trend, except for the unemployment rate and the long-term rate, which are expressed in monthly percentage points and annualized basis points (ABP), respectively.

A.5.4 Forecast Error Variance Decomposition

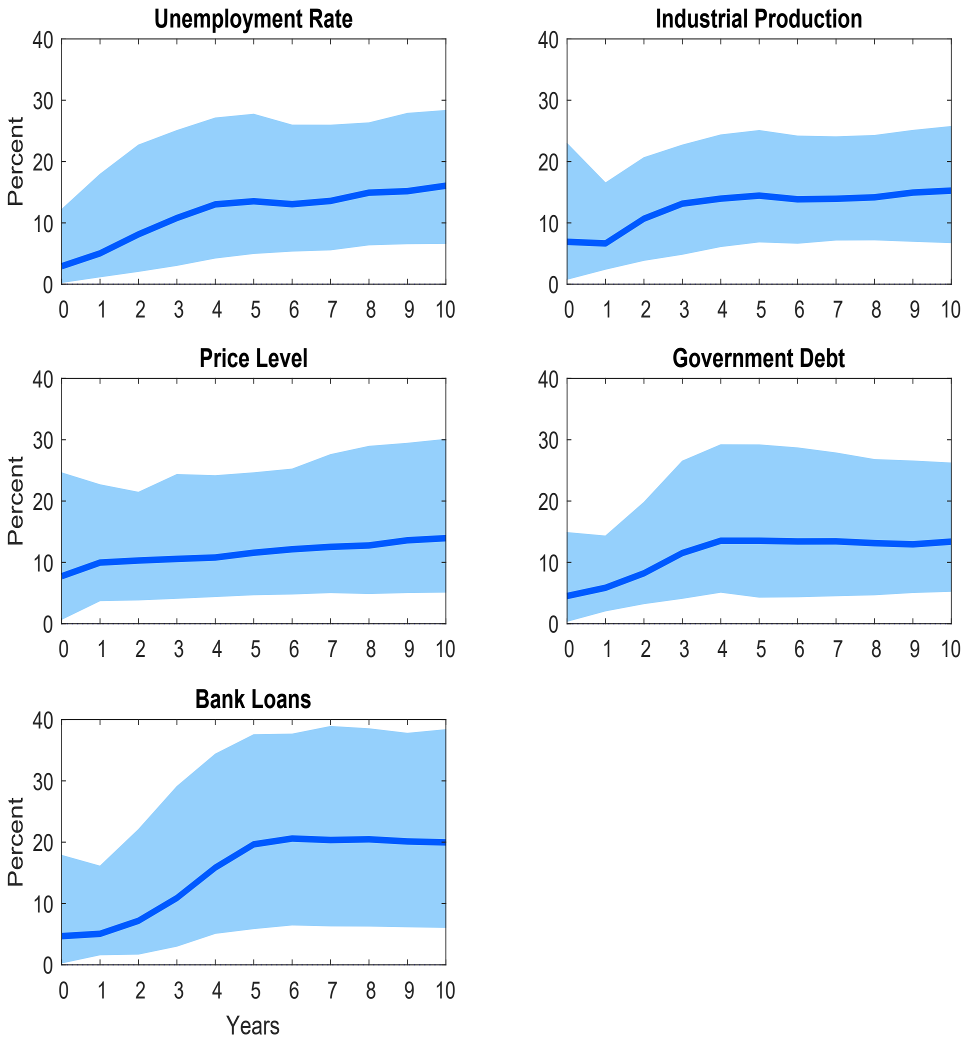

Figure 31: Decomposition of Variance

Note: Variance decomposition in selected variables due to sovereign uncertainty shocks under the baseline identification with sign, event-based and ratio restrictions. Figures are expressed in percent for each VAR forecast horizon (up to 10 years). Each entry shows the median and the 68% credible bands of the FEVD distribution. The empirical sample is from May 1997 to December 2019.

A.5.5 Historical Decomposition

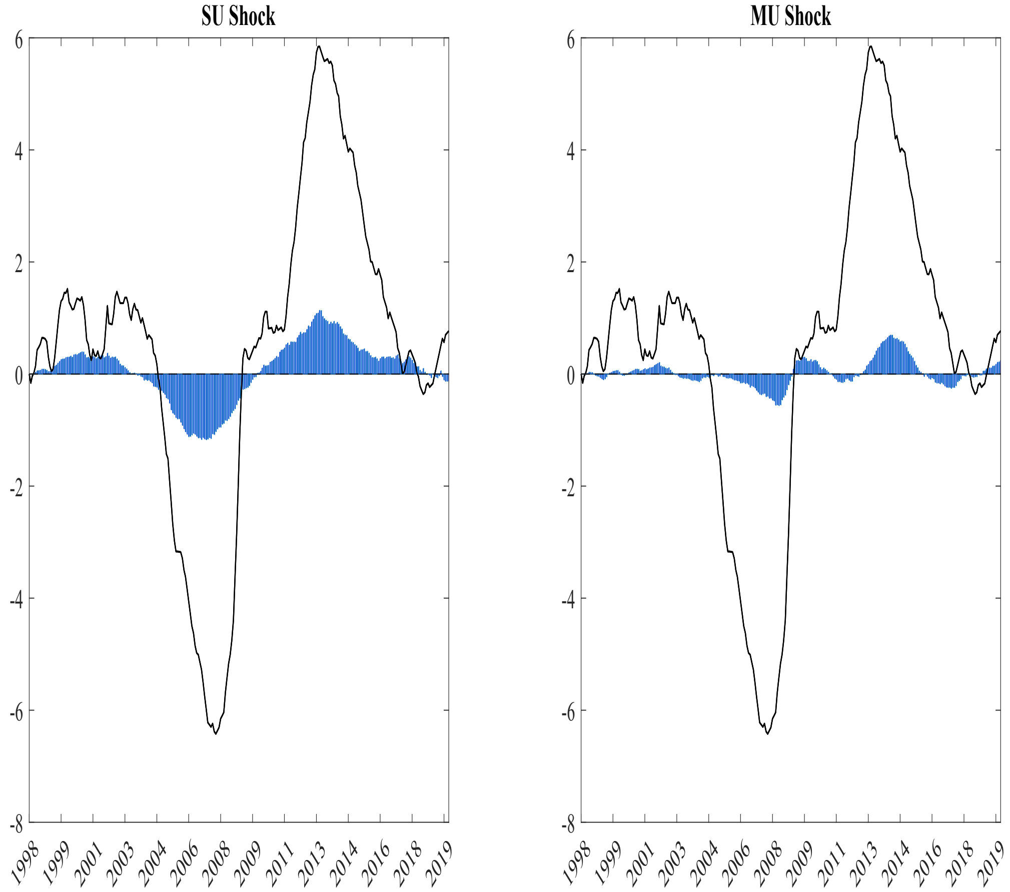

Figure 32: Historical Decomposition of Unemployment Rate

Note: Historical decomposition in selected variables due to SU and MU shocks under the baseline identification with sign, event-based and ratio restrictions. Figures are expressed in percent. The empirical sample is from May 1997 to December 2019.

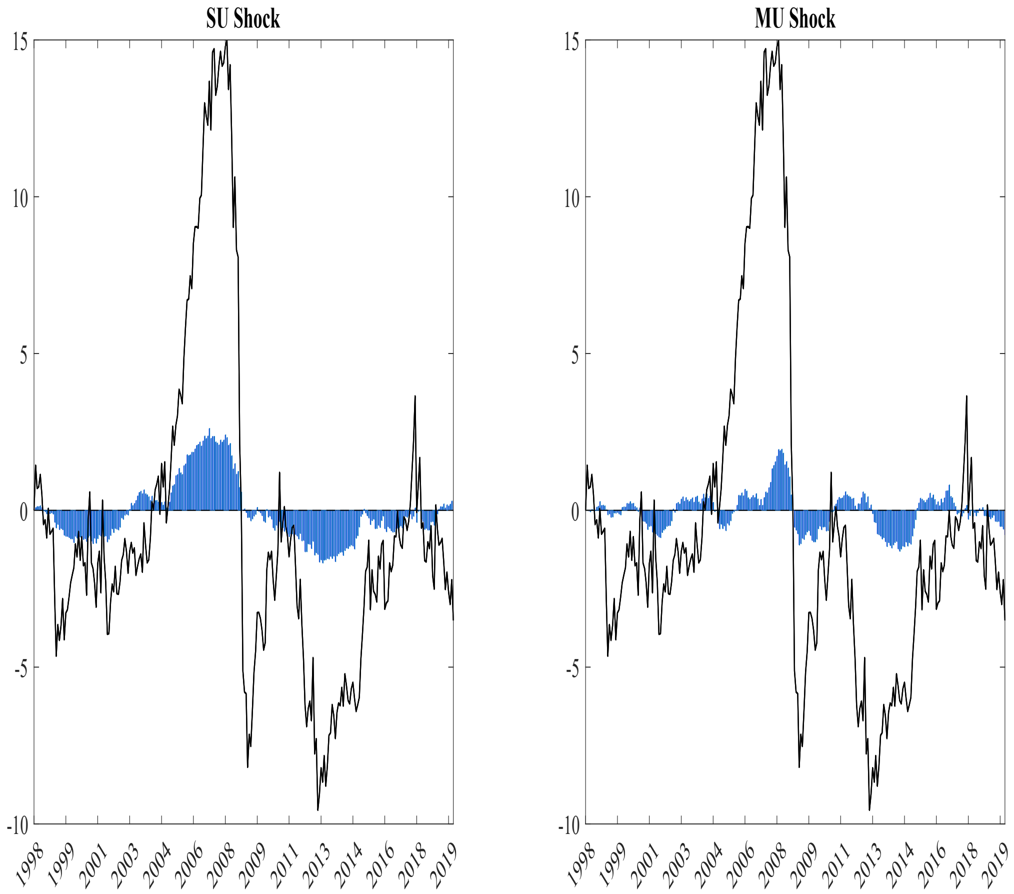

Figure 33: Historical Decomposition of Industrial Production

Note: Historical decomposition in selected variables due to SU and MU shocks under the baseline identification with sign, event-based and ratio restrictions. Figures are expressed in percent. The empirical sample is from May 1997 to December 2019.

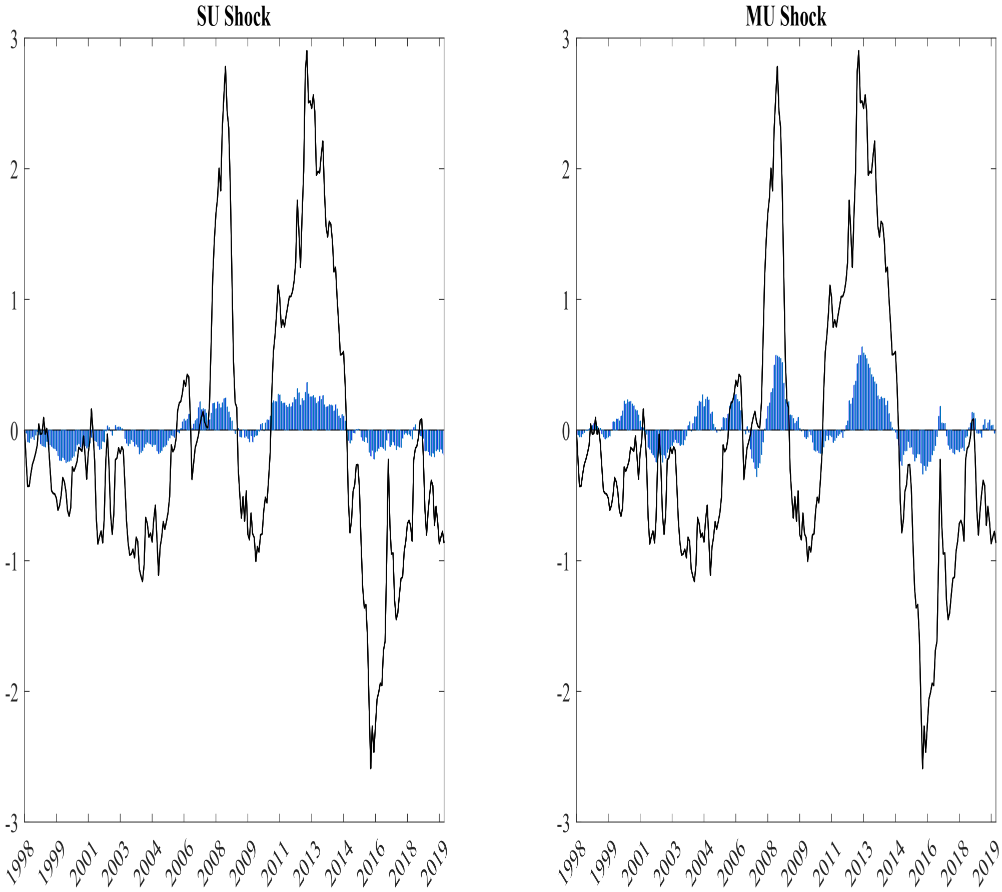

Figure 34: Historical Decomposition of CPI

Note: Historical decomposition in selected variables due to SU and MU shocks under the baseline identification with sign, event-based and ratio restrictions. Figures are expressed in percent. The empirical sample is from May 1997 to December 2019.

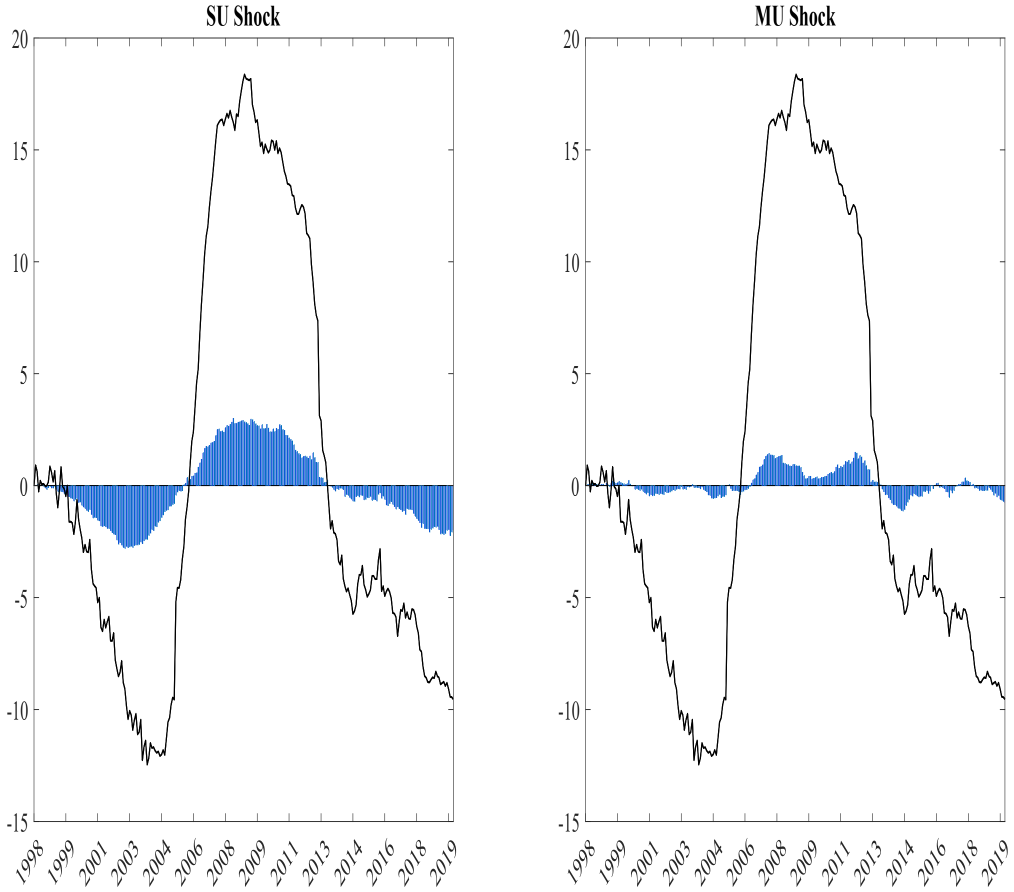

Figure 35: Historical Decomposition of Bank Loans

Note: Historical decomposition in selected variables due to SU and MU shocks under the baseline identification with sign, event-based and ratio restrictions. Figures are expressed in percent. The empirical sample is from May 1997 to December 2019.

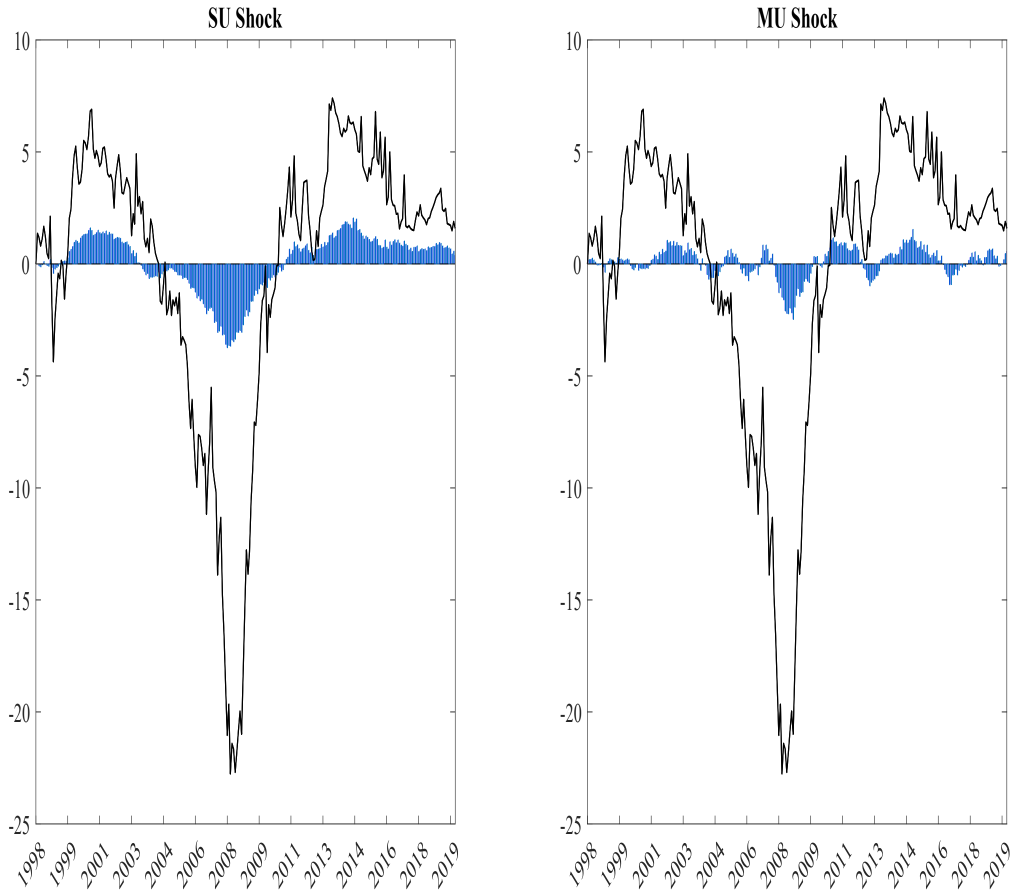

Figure 36: Historical Decomposition of Government Debt

Note: Historical decomposition in selected variables due to SU and MU shocks under the baseline identification with sign, event-based and ratio restrictions. Figures are expressed in percent. The empirical sample is from May 1997 to December 2019.

A.5.6 Estimated Shocks Series

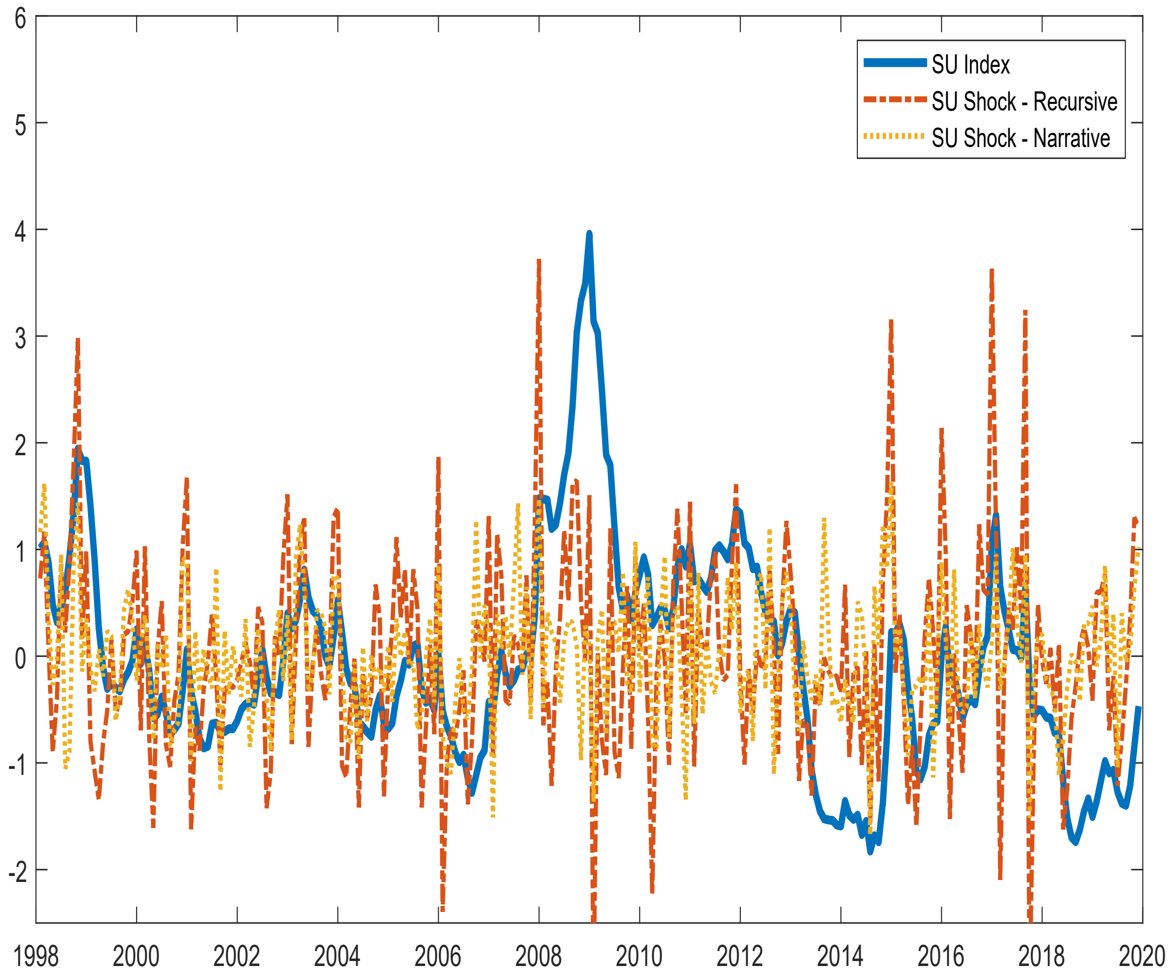

Figure 37: SU Index and SU Shocks

Note: The solid-blue line indicates the constructed SU index; the dash-dot-orange line represents the estimated SU shocks under the recursive identification; and the dotted-yellow line exhibits the estimated SU shocks under the identification with sign, event-based and ratio restrictions.

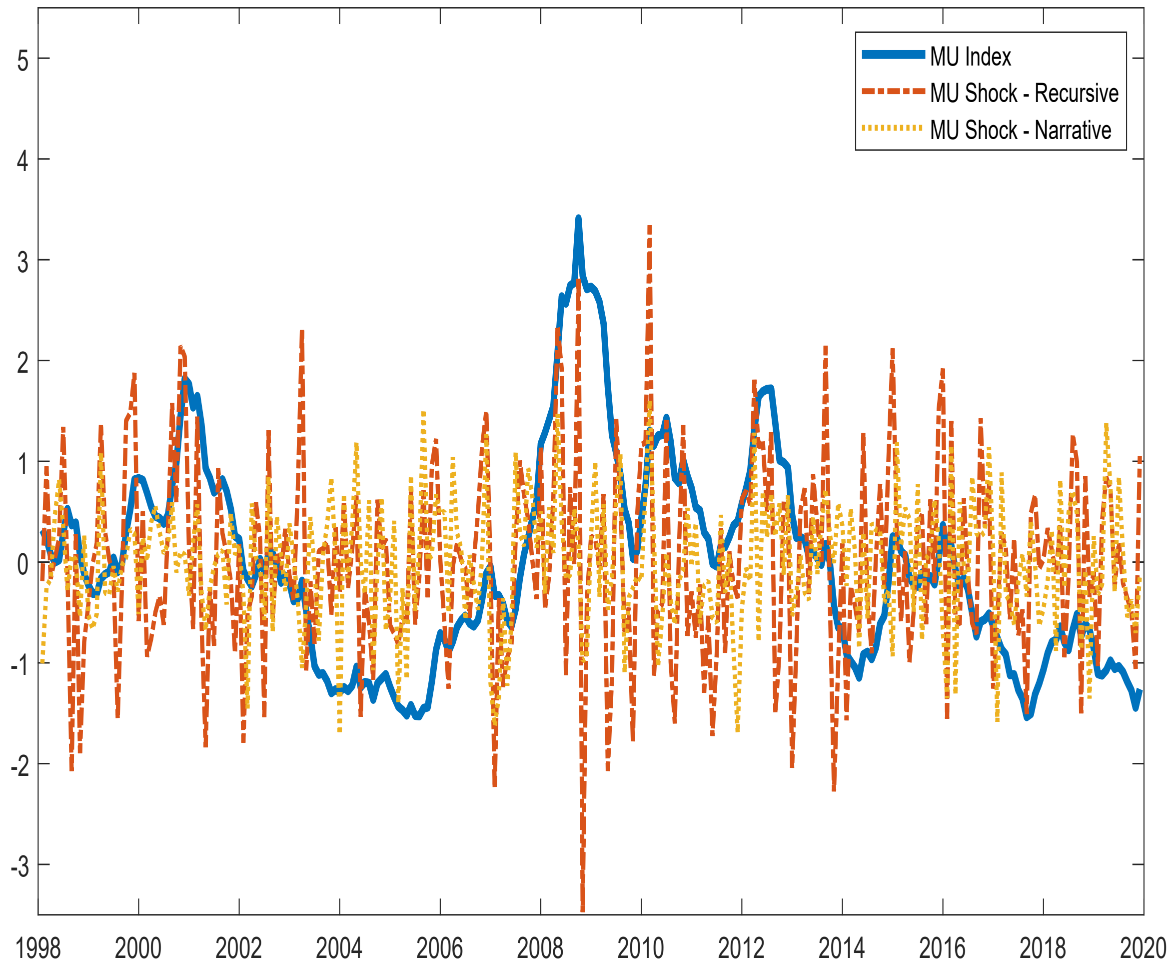

Figure 38: MU Index and MU Shocks

Note: The solid-blue line indicates the constructed MU index; the dash-dot-orange line represents the estimated MU shocks under the recursive identification; and the dotted-yellow line exhibits the estimated MU shocks under the identification with sign, event-based and ratio restrictions.

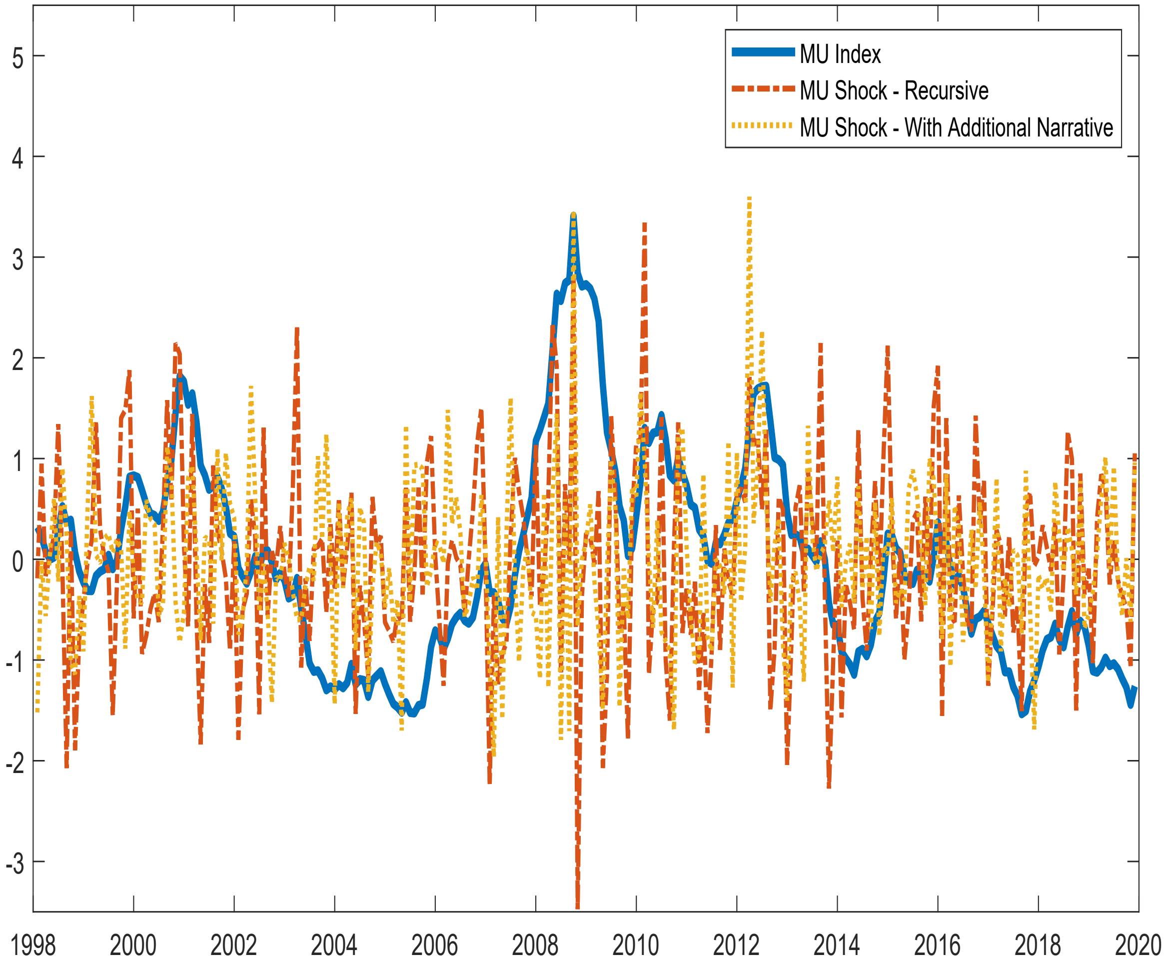

Figure 39: MU Index and MU Shocks: Additional Narrative

Note: The solid-blue line indicates the constructed MU index; the dash-dot-orange line represents the estimated MU shocks under the recursive identification; and the dotted-yellow line exhibits the estimated MU shocks under the variant of the baseline narrative identification: The MU shock is the most important contributor to the unexpected changes observed in the MU index following the Lehman Brothers' Collapse (September-October 2008).

A.6 The (Non-linear) Transmission of SU Shocks

The Threshold VAR is defined as follows:

$$y_t = \left(c_1 + \sum_{k=1}^{p} \beta_{1,k} y_{t-k} + \epsilon_{1,t}\right) \times S_t + \left(c_2 + \sum_{k=1}^{p} \beta_{2,k} y_{t-k} + \epsilon_{2,t}\right) \times (1 - S_t), \qquad (51)$$

with

$$S_t = \begin{cases} 1 & if \;\; r_{t-d} \leq \bar{r} \\ 0 & otherwise \end{cases} \qquad (52)$$

and

$$\epsilon_{1,t} \sim \mathbb{N}(0,\, Q_1) \;\; \text{and} \;\; \epsilon_{2,t} \sim \mathbb{N}(0,\, Q_2),$$

where y_t stands for the vector of endogenous variables, c_i are constants in the respective regimes, and $\epsilon_{i,t}$ are Gaussian white noise shocks with covariance matrices Q_i, $\forall j$ =

1, 2. Different from the linear VAR, coefficients c_i and β_i are regimen-dependent. The state prevailing in each period depends on whether the level of the threshold variable, which in my case is represented by the change in the year-on-year unemployment rate, is above or below a latent threshold level. This proxy, aimed at capturing recessions and expansions, is consistent with previous empirical evidence that analyzes the non-linear effects of uncertainty shocks.[46]

In this extended version, the conjugate Normal-inverse Wishart prior (for the VAR parameter vector in both regimes) is implemented via dummy observations (Bańbura et al., 2010). The prior means of the coefficients on the first lag are set to one for non-stationary variables, and set to zero otherwise. The overall prior tightness is set to 0.10 and the prior on the intercept to 0.01. For the latent threshold level, $\bar{r}$, it is assumed a normal prior, and for the delay, d, a uniform prior with a maximum delay of nine months. While the posterior distribution of the VAR parameter vector is known (conditional now on the values of $\bar{r}$ and d), the posterior distributions of $\bar{r}$ and d conditional on the VAR coefficients are unknown. Therefore, I employ the Gibbs (MCMC) sampler introduced by Chen and Lee (1995) to simulate the posterior distribution of the model's parameters with 20,000 replications. I discard the first 15,000 iterations as burn-in and use the last 5,000 for inference.

The observables are sovereign uncertainty, bank lending, industrial production, unemployment rate and macro-financial uncertainty. Again, I use Spanish monthly data in log-levels for all variables except those expressed in rates (see Appendix A.1.3 for data description). The sample is from May 1997 to December 2019 and the model features nine lags. The reason for this reduced system is as follows. First, a non-linear VAR model is particularly rich in terms of coefficients to be estimated and thus requires the inclusion of a smaller set of indicators, especially if I have already selected nine lags. Moreover, as I have previously shown in the main text, the dynamics for the main indicators of interest — bank lending, industrial production and unemployment rate — were highly robust after a large battery of checks. In other words, the inclusion or exclusion of other economic aggregates in the vector of observables did not change their particular conclusions.

Following Koop et al. (1996), I compute the generalized impulse response functions (GIRFs) as the difference between two conditional expectations since the TVAR is non-linear:

$$GIRF_t = \mathbb{E}[y_{t+h}|\xi, \Theta_{t-1}] - \mathbb{E}[y_{t+h}|\Theta_{t-1}], \tag{53}$$

where h is the considered horizon, ξ is the size of the shock and Θ_{t-1} is a set of initial conditions which is formed by the parameters of the model. For each history, I compute 500 time paths of length h. Then, I average the GIRFs over all histories in each regime.[47]

Figure 40 shows the two different regimes that the model endogenously identifies by using the inverse of the unemployment rate as a threshold. Dashed-grey areas indicate the estimated bust regimes (proxied by high unemployment rates). Hence, by definition, recessions (expansions) occur when the level of the threshold variable is below (above) the latent threshold level. It is worth noting that estimated recessions are almost identical to the ones considered by the Spanish Business Cycle Dating Committee and the Economic

[46] Given that the Gross Value Added of the service sector is relatively high in the Spanish economy, I have employed the unemployment rate as a threshold variable.

[47] The model can switch across the endogenous states conditional on the sign and the size of the shock.

Cycle Research Institute (ECRI) during the twin global financial crisis and eurozone debt crisis. Moreover, the threshold variable also determines the span 2002–2003 as a short episode of economic slowdown. While this limited period is not dated by the previous institutions, it is reflected in the Spanish EPU index as a high uncertainty event.

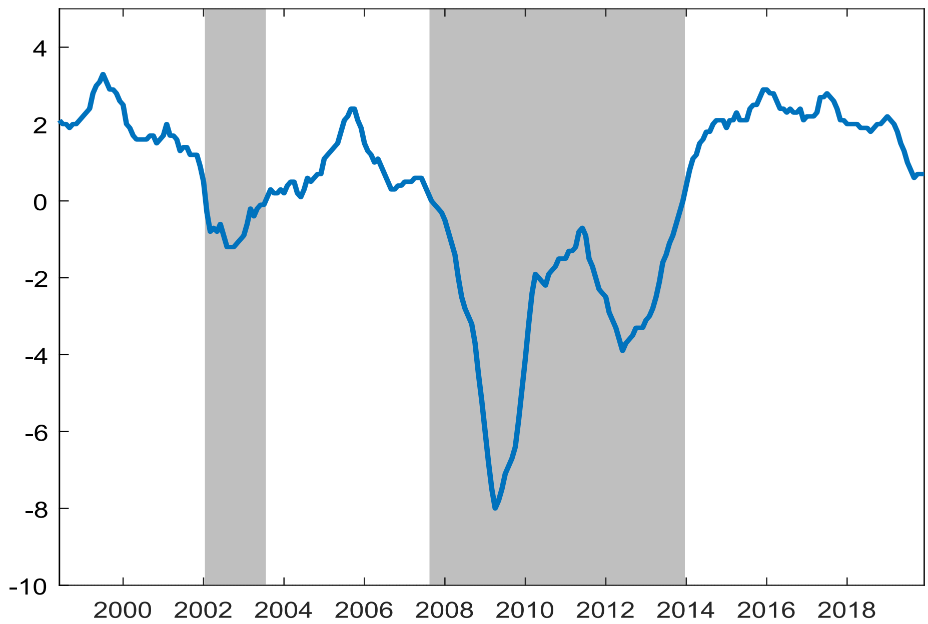

Figure 40: Threshold Dynamics

Note: Dashed-grey areas indicate the estimated bust regimes.

Next, Figure 41 plots the generalized impulse response functions (GIRFs) to a one standard deviation shock to sovereign uncertainty in the Threshold VAR model.[48] On the one hand, we can observe that following a shock to SU during recessions, industrial production decreases on impact by around -0.2% and reaches a value of -0.75% after one years. On the other hand, when the economy is in normal times, industrial production goes down only as time passes and hits the bottom with a value of -0.5%. The same analysis applies to the unemployment rate, i.e., the impact is larger in bad times but still substantial in good times.

[48]The GIRFs are built on draws from the joint distribution of the structural shocks as in Kilian and Vigfusson (2011). In this case, I only claim that I identify one structural shock based on a Cholesky recursion: a sovereign uncertainty shock. The innovations associated with the remaining endogenous variables of the model are left without interpretation.

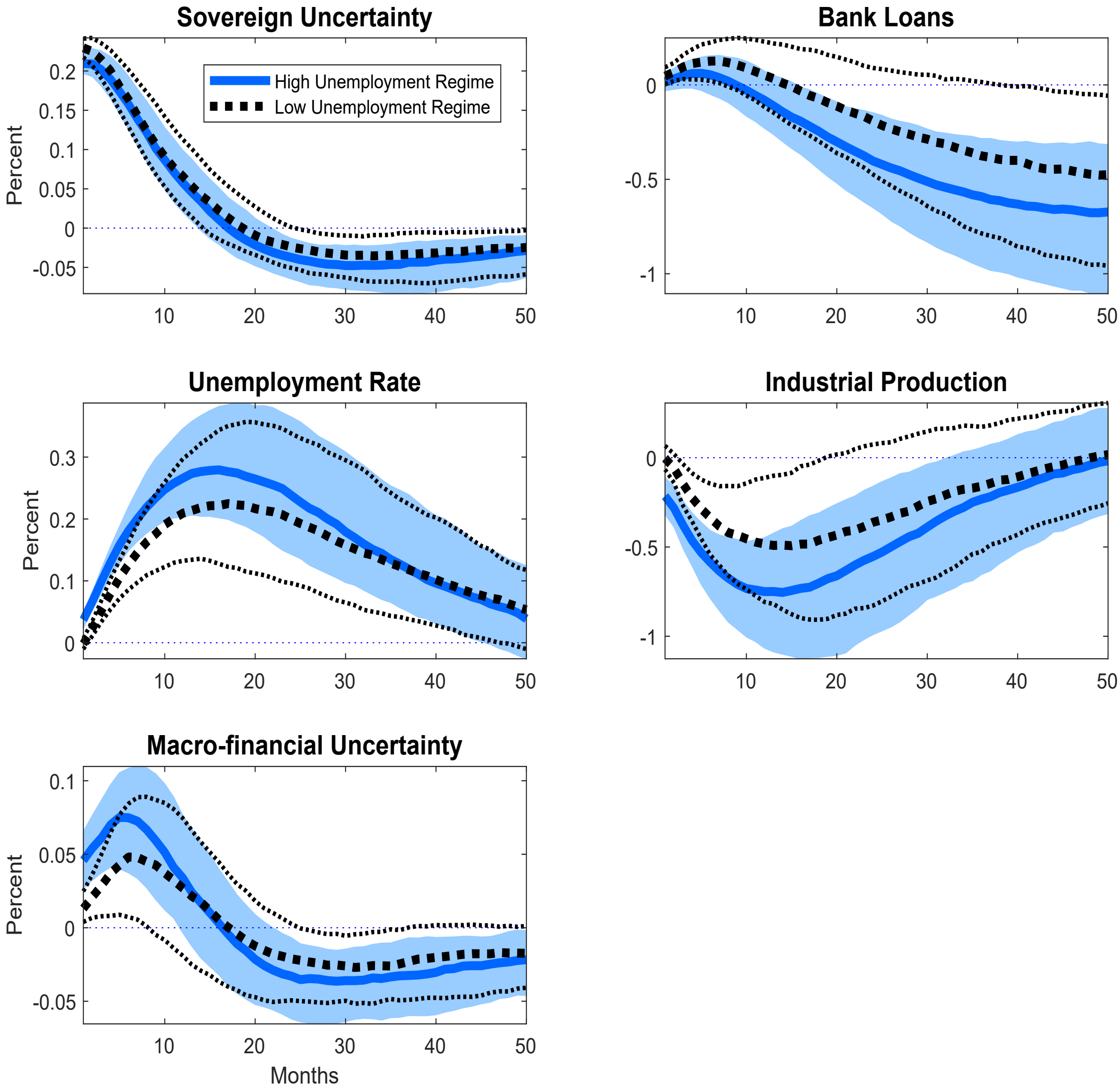

Figure 41: GIRFs to One Standard Deviation Shock to Sovereign Uncertainty

Note: Each entry shows the median and the 68% credible bands. All responses are in monthly percent deviations from trend, except for the unemployment rate, which is expressed in monthly percentage points.

B Theoretical Section

B.1 Quarterly IRFs for Moment Matching

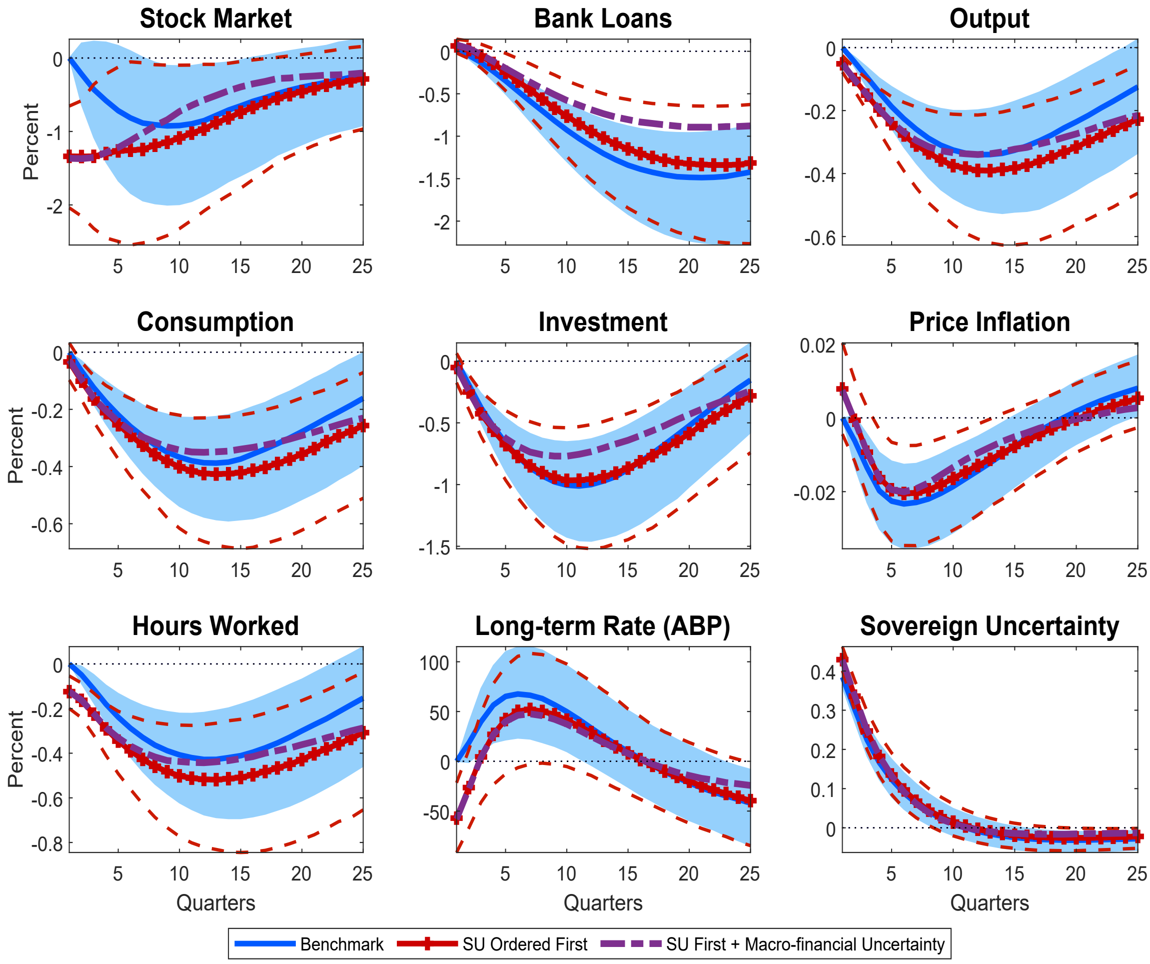

Figure 42: Quarterly IRFs to One Standard Deviation Shock to Sovereign Uncertainty

Note: Each entry shows the median and the 68% credible bands. All responses are in quarterly percent deviations from trend, except for inflation and the long-term rate, which are expressed in quarterly percentage points and annualized basis points (ABP), respectively.

B.2 Monetary Policy Decisions without Direct Influence from SU Shocks and Higher Bank's Leverage Ratio

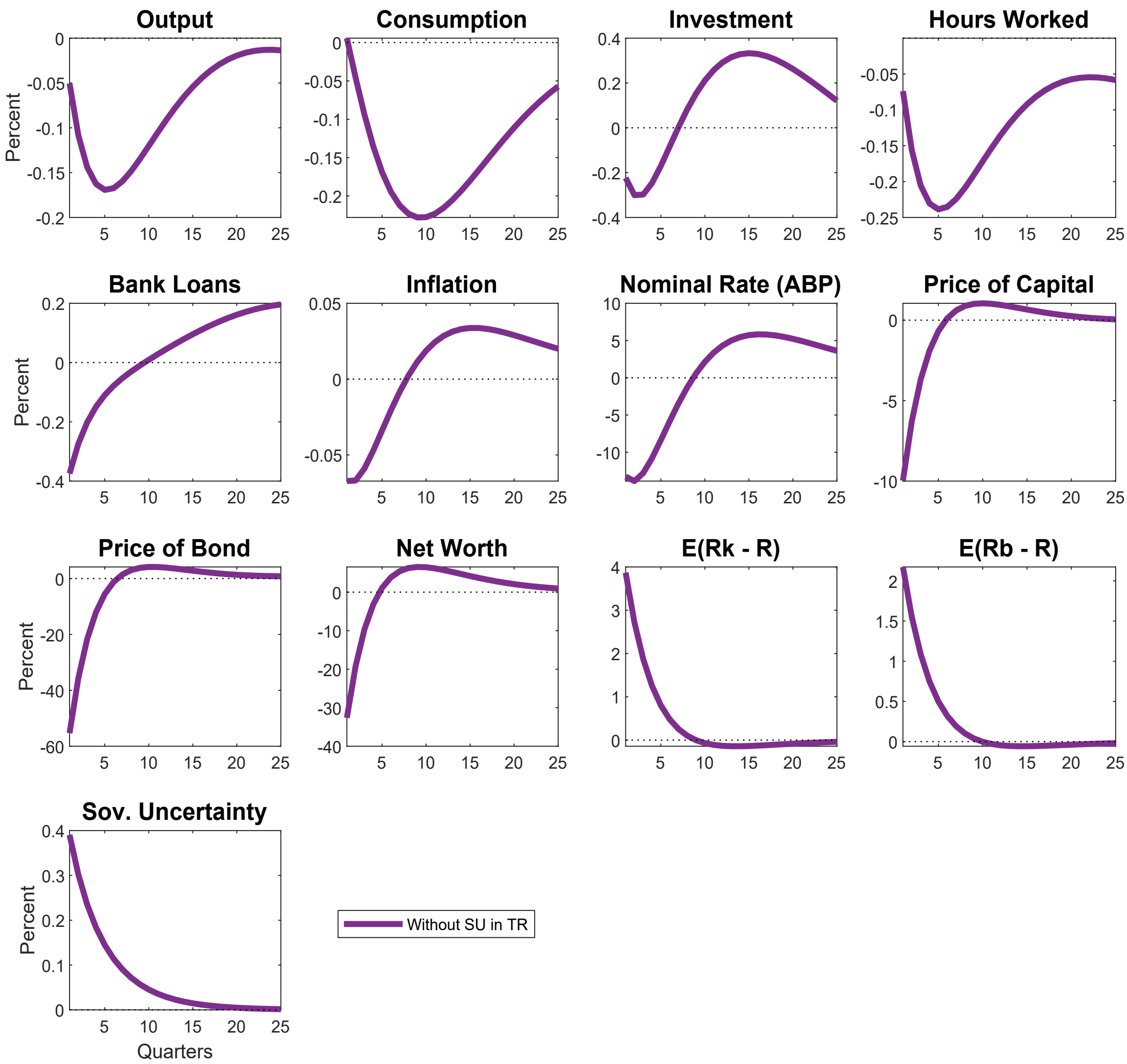

Figure 43: Quarterly IRFs to One Standard Deviation Shock to Sovereign Uncertainty: without SU Shocks in the Taylor Rule and Higher Bank's Leverage Ratio

Note: All responses are in quarterly percent deviations from the stochastic steady state, except for inflation and the nominal interest rate, which are expressed in quarterly percentage points and annualized basis points (ABP), respectively. For this exercise, I set $\kappa_{\sigma_{RB}} = 0$, $\lambda = 0.25$ and $\theta = 0.96$.

B.3 Higher Risk Aversion and the Role of the Elasticity of Intertemporal Substitution

Figure 44 compares SU and MU shocks when households exhibit higher risk aversion (from $\sigma = 5$ to $\sigma = 25$). Similar to the experiment concerning the role of nominal rigidities, different values of risk aversion appear to have a more significant impact in the case of MU shocks than for SU shocks.

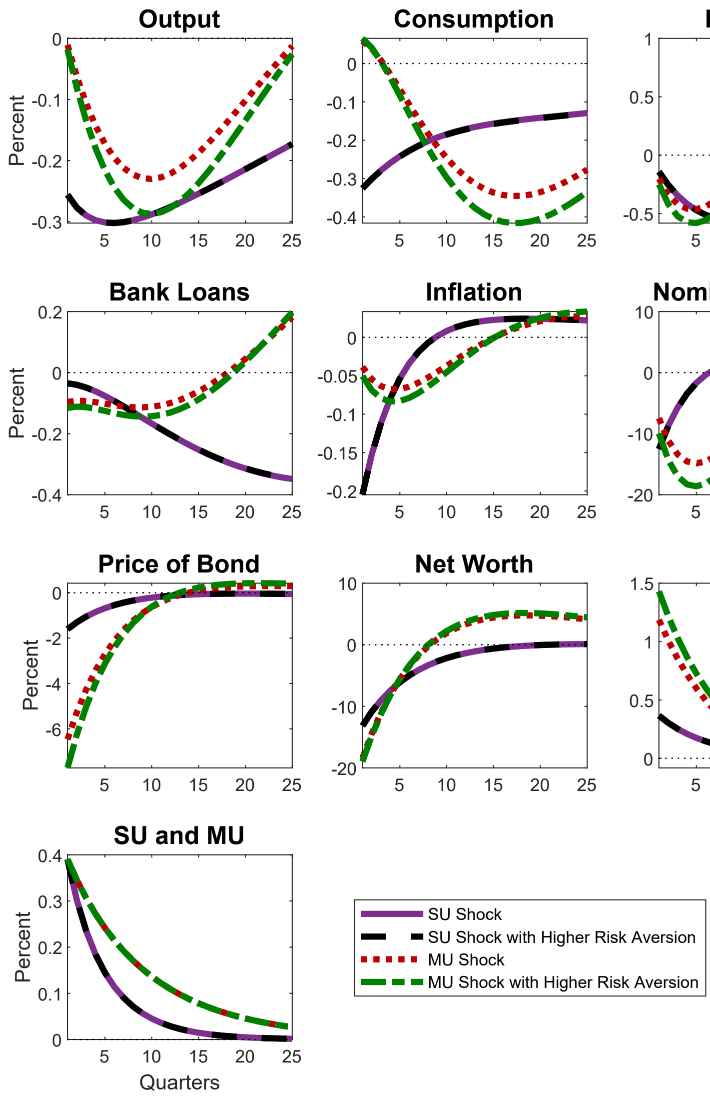

Figure 44: Quarterly IRFs to One Standard Deviation Shock to SU and MU: Higher Risk Aversion

Note: All responses are in quarterly percent deviations from the stochastic steady state, except for inflation and the nominal interest rate, which are expressed in quarterly percentage points and annualized basis points (ABP), respectively.

When uncertainty arises from the real sector — involving second-moment shocks to TFP or household preferences as in Basu and Bundick (2017) — higher risk aversion immediately affects labour supply and private consumption decisions (see Appendix D.5 in

Basu and Bundick, 2017). However, uncertainty originating from public finances directly impacts banks' portfolios and is transmitted to the real economy afterward, making the relevance of risk aversion more limited. Consequently, the precautionary labor supply by households after a SU shock mainly depends on the quantity of risk, i.e., the size of the shock. In Cesa-Bianchi and Fernandez-Corugedo (2018), one of their measures of uncertainty is associated with a higher probability of entrepreneurial bankruptcy, and the amplification effect stemming from risk aversion is relatively small (and only on impact).

Finally, results regarding higher EIS are displayed in Figure 45 (from $\psi = 0.5$ to $\psi = 0.95$). As observed, a higher EIS is associated with larger effects on the macroeconomy, particularly for bank loans and investment. In this case, the additional impact aligns with the findings in Born and Pfeifer (2014) and Basu and Bundick (2017).

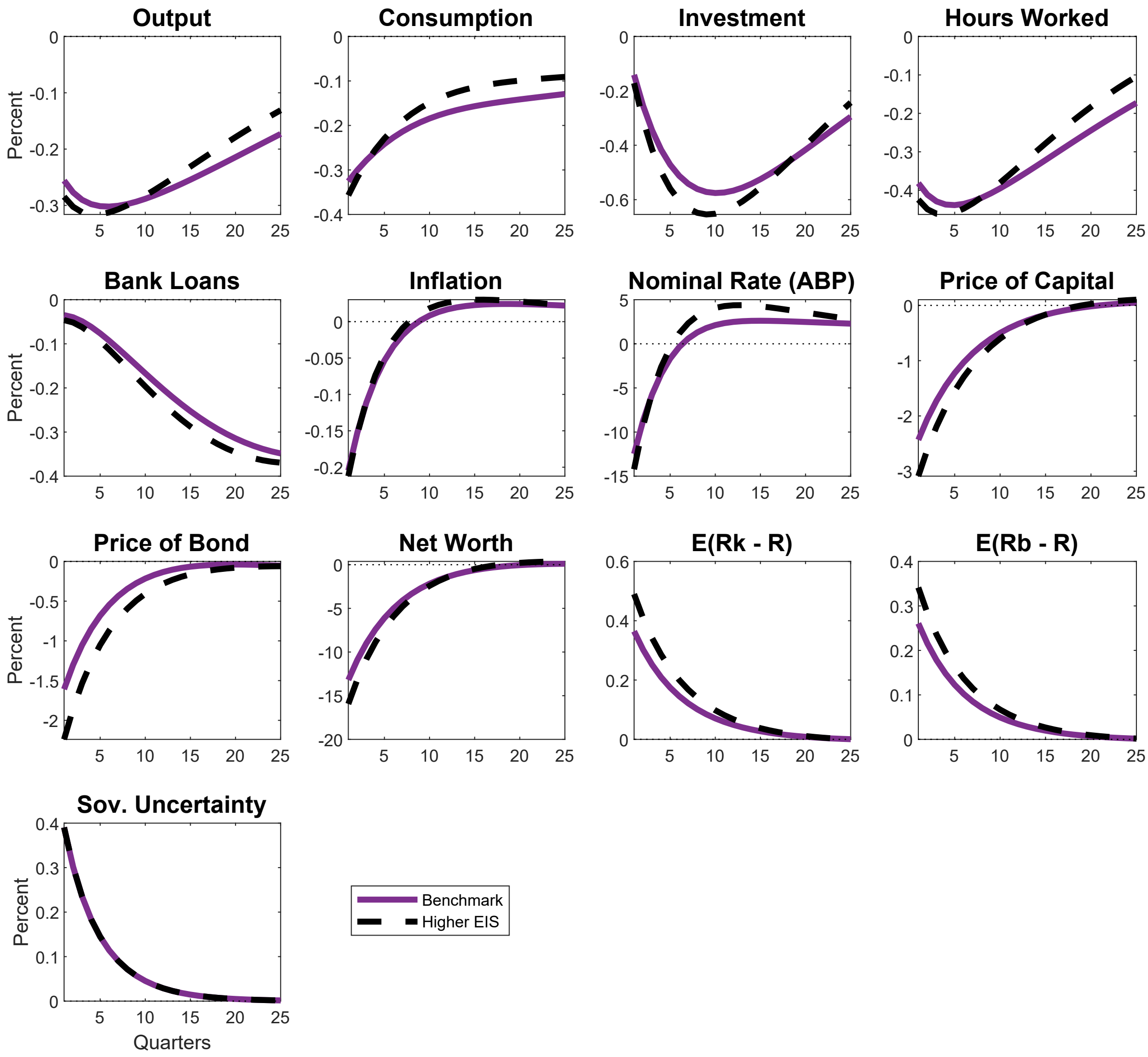

Figure 45: Quarterly IRFs to One Standard Deviation Shock to Sovereign Uncertainty: Higher EIS

Note: All responses are in quarterly percent deviations from the stochastic steady state, except for inflation and the nominal interest rate, which are expressed in quarterly percentage points and annualized basis points (ABP), respectively.

B.4 Structural VARs on Simulated Data from the DSGE Model

I simulate the DSGE model and estimate SVARs using the simulated data. The empirical strategy is based on the one presented in Section 4.3 for four reasons: *i*) the time period in the theoretical model corresponds to one-quarter; *ii*) several variables in the DSGE model are only expressed in quarterly terms (GDP, consumption and investment); *iii*) its recursive setup permits clear isolation of the economic mechanisms driving the propagation of SU and MU shocks, which makes the DSGE and SVAR models more comparable; and *iv*) the timing of the narrative restrictions is on a monthly basis, and consequently, justifying the episodes in quarterly terms becomes more challenging.

Specifically, I follow Basu and Bundick (2017) and run 10,000 SVARs, each estimated using the simulated data from the theoretical model. Figure 46 and Figure 47 depict the median IRFs along with the probability interval, versus the true responses from the DSGE model. It is worth noting that, given this specific strategy to construct the responses, the frequentist interval is 95% instead of the standard 68% Bayesian credible bands reported previously.

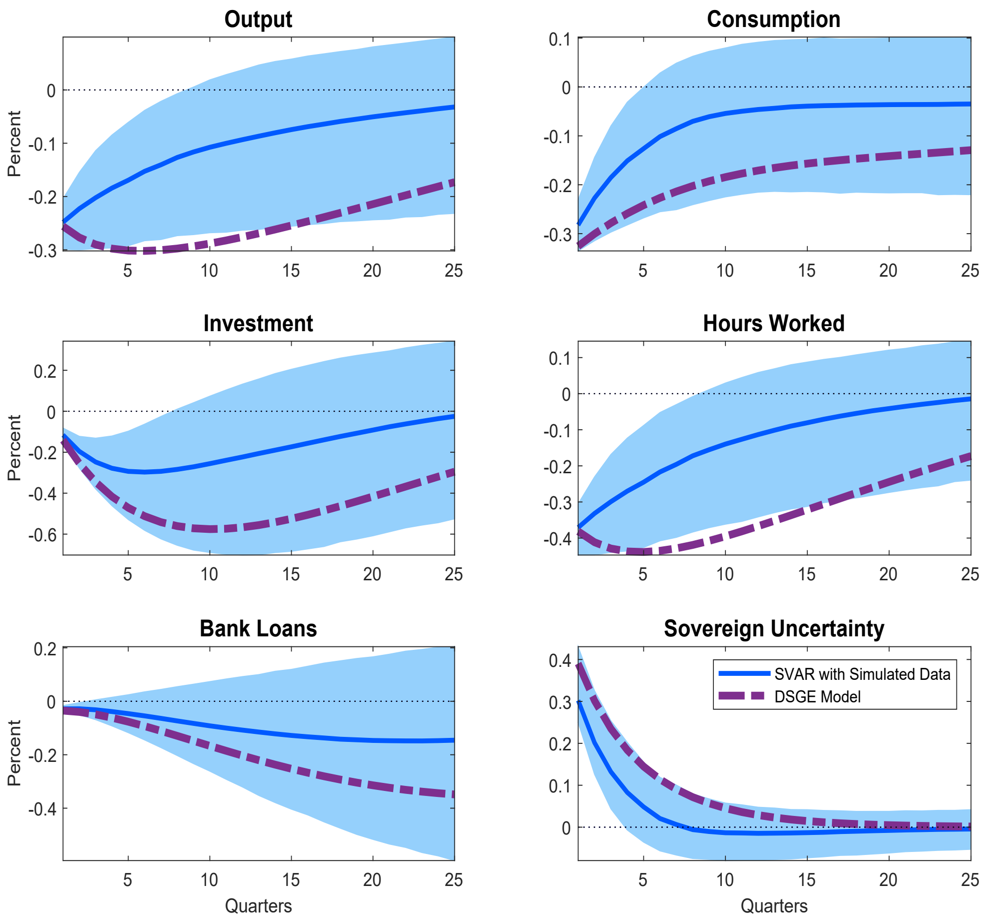

Figure 46: Computing Structural VARs on Simulated Data from the DSGE Model: SU shocks

Note: All responses are in quarterly percent deviations from the stochastic steady state.

As observed, the empirical methodology broadly succeeds in capturing the true IRFs from the theoretical model, especially in the aftermath of a SU shock. As explained in the main text, MU shocks are less persistent and require more volatility compared to SU shocks. However, this more volatile shock process implies excessive unconditional volatility in the economic aggregates. Lastly, the average correlation is 0.85 (0.74) between the true SU (MU) shocks, $\sigma_{RB,t}$ ($\sigma_{A,t}$), and the identified SU (MU) shocks from each structural VAR.

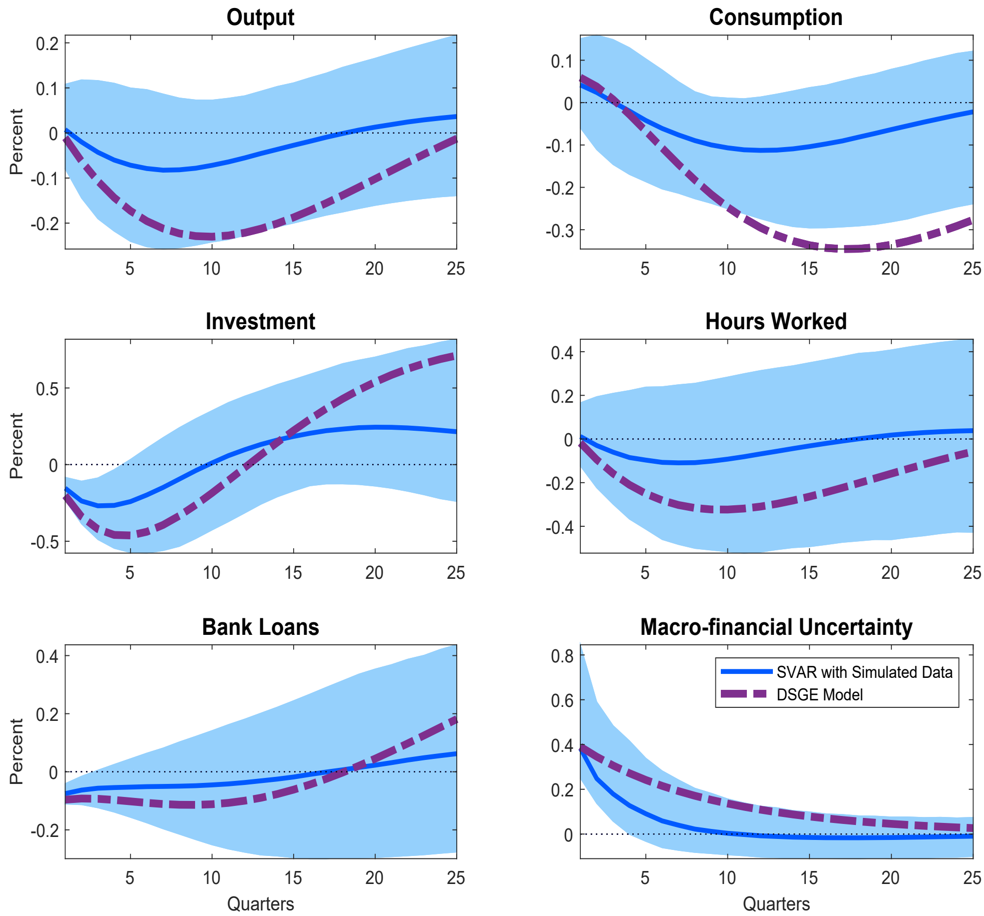

Figure 47: Computing Structural VARs on Simulated Data from the DSGE Model: MU shocks

Note: All responses are in quarterly percent deviations from the stochastic steady state.

BANCO DE ESPAÑA PUBLICATIONS

WORKING PAPERS

2241 JULIO GÁLVEZ and GONZALO PAZ-PARDO: Richer earnings dynamics, consumption and portfolio choice over the life cycle.
2242 MARINA DIAKONOVA, CORINNA GHIRELLI, LUIS MOLINA and JAVIER J. PÉREZ: The economic impact of conflict-related and policy uncertainty shocks: the case of Russia.
2243 CARMEN BROTO, LUIS FERNÁNDEZ LAFUERZA and MARIYA MELNYCHUK: Do buffer requirements for European systemically important banks make them less systemic?
2244 GERGELY GANICS and MARÍA RODRÍGUEZ-MORENO: A house price-at-risk model to monitor the downside risk for the Spanish housing market.
2245 JOSÉ E. GUTIÉRREZ and LUIS FERNÁNDEZ LAFUERZA: Credit line runs and bank risk management: evidence from the disclosure of stress test results.
2301 MARÍA BRU MUÑOZ: The forgotten lender: the role of multilateral lenders in sovereign debt and default.
2302 SILVIA ALBRIZIO, BEATRIZ GONZÁLEZ and DMITRY KHAMETSHIN: A tale of two margins: monetary policy and capital misallocation.
2303 JUAN EQUIZA, RICARDO GIMENO, ANTONIO MORENO and CARLOS THOMAS: Evaluating central bank asset purchases in a term structure model with a forward-looking supply factor.
2304 PABLO BURRIEL, IVÁN KATARYNIUK, CARLOS MORENO PÉREZ and FRANCESCA VIANI: New supply bottlenecks index based on newspaper data.
2305 ALEJANDRO FERNÁNDEZ-CEREZO, ENRIQUE MORAL-BENITO and JAVIER QUINTANA: A production network model for the Spanish economy with an application to the impact of NGEU funds.
2306 MONICA MARTINEZ-BRAVO and CARLOS SANZ: Trust and accountability in times of pandemic.
2307 NATALIA FABRA, EDUARDO GUTIÉRREZ, AITOR LACUESTA and ROBERTO RAMOS: Do renewable energies create local jobs?
2308 ISABEL ARGIMÓN and IRENE ROIBÁS: Debt overhang, credit demand and financial conditions.
2309 JOSÉ-ELÍAS GALLEGOS: Inflation persistence, noisy information and the Phillips curve.
2310 ANDRÉS ALONSO-ROBISCO, JOSÉ MANUEL CARBÓ and JOSÉ MANUEL MARQUÉS: Machine Learning methods in climate finance: a systematic review.
2311 ALESSANDRO PERI, OMAR RACHEDI and IACOPO VAROTTO: The public investment multiplier in a production network.
2312 JUAN S. MORA-SANGUINETTI, JAVIER QUINTANA, ISABEL SOLER and ROK SPRUK: Sector-level economic effects of regulatory complexity: evidence from Spain.
2313 CORINNA GHIRELLI, ENKELEJDA HAVARI, ELENA MERONI and STEFANO VERZILLO: The long-term causal effects of winning an ERC grant.
2314 ALFREDO GARCÍA-HIERNAUX, MARÍA T. GONZÁLEZ-PÉREZ and DAVID E. GUERRERO: How to measure inflation volatility. A note.
2315 NICOLÁS ABBATE, INÉS BERNIELL, JOAQUÍN COLEFF, LUIS LAGUINGE, MARGARITA MACHELETT, MARIANA MARCHIONNI, JULIÁN PEDRAZZI and MARÍA FLORENCIA PINTO: Discrimination against gay and transgender people in Latin America: a correspondence study in the rental housing market.
2316 SALOMÓN GARCÍA: The amplification effects of adverse selection in mortgage credit suply.
2317 METTE EJRNÆS, ESTEBAN GARCÍA-MIRALLES, METTE GØRTZ and PETTER LUNDBORG: When death was postponed: the effect of HIV medication on work, savings and marriage.
2318 GABRIEL JIMÉNEZ, LUC LAEVEN, DAVID MARTÍNEZ-MIERA and JOSÉ-LUIS PEYDRÓ: Public guarantees and private banks' incentives: evidence from the COVID-19 crisis.
2319 HERVÉ LE BIHAN, DANILO LEIVA-LEÓN and MATÍAS PACCE: Underlying inflation and asymmetric risks.
2320 JUAN S. MORA-SANGUINETTI, LAURA HOSPIDO and ANDRÉS ATIENZA-MAESO: The numbers of equality regulation. Quantifying regulatory activity on non-discrimination and its relationship with gender gaps in the labour market.
2321 ANDRES ALONSO-ROBISCO and JOSÉ MANUEL CARBÓ: Analysis of CBDC Narrative of Central Banks using Large Language Models.
2322 STEFANIA ALBANESI, ANTÓNIO DIAS DA SILVA, JUAN F. JIMENO, ANA LAMO and ALENA WABITSCH: New technologies and jobs in Europe.
2323 JOSÉ E. GUTIÉRREZ: Optimal regulation of credit lines.
2324 MERCEDES DE LUIS, EMILIO RODRÍGUEZ and DIEGO TORRES: Machine learning applied to active fixed-income portfolio management: a Lasso logit approach.

2325 SELVA BAHAR BAZIKI, MARÍA J. NIETO and RIMA TURK-ARISS: Sovereign portfolio composition and bank risk: the case of European banks.

2326 ANGEL-IVAN MORENO and TERESA CAMINERO: Assessing the data challenges of climate-related disclosures in european banks. A text mining study.

2327 JULIO GÁLVEZ: Household portfolio choices under (non-)linear income risk: an empirical framework.

2328 NATASCHA HINTERLANG: Effects of Carbon Pricing in Germany and Spain: An Assessment with EMuSe.

2329 RODOLFO CAMPOS, SAMUEL PIENKNAGURA and JACOPO TIMINI: How far has globalization gone? A tale of two regions.

2330 NICOLÁS FORTEZA and SANDRA GARCÍA-URIBE: A Score Function to Prioritize Editing in Household Survey Data: A Machine Learning Approach.

2331 PATRICK MACNAMARA, MYROSLAV PIDKUYKO and RAFFAELE ROSSI: Taxing consumption in unequal economies.

2332 ESTHER CÁCERES and MATÍAS LAMAS: Dividend Restrictions and Search for Income.

2333 MARGARITA MACHELETT: Gender price gaps and competition: Evidence from a correspondence study.

2334 ANTON NAKOV and CARLOS THOMAS: Climate-conscious monetary policy.

2335 RICARDO BARAHONA, STEFANO CASSELLA and KRISTY A. E. JANSEN: Do teams alleviate or exacerbate the extrapolation bias in the stock market?

2336 JUAN S. MORA-SANGUINETTI and ANDRÉS ATIENZA-MAESO: “Green regulation”: A quantification of regulations related to renewable energy, sustainable transport, pollution and energy efficiency between 2000 and 2022.

2401 LAURA HOSPIDO, NAGORE IRIBERRI and MARGARITA MACHELETT: Gender gaps in financial literacy: a multi-arm RCT to break the response bias in surveys.

2402 RUBÉN DOMÍNGUEZ-DÍAZ, SAMUEL HURTADO and CAROLINA MENÉNDEZ: The medium-term effects of investment stimulus.

2403 CLODOMIRO FERREIRA, JOSÉ MIGUEL LEIVA, GALO NUÑO, ÁLVARO ORTIZ, TOMASA RODRIGO and SIRENIA VAZQUEZ: The heterogeneous impact of inflation on households’ balance sheets.

2404 JORGE ABAD, GALO NUÑO and CARLOS THOMAS: CBDC and the operational framework of monetary policy.

2405 STÉPHANE BONHOMME and ANGELA DENIS: Estimating individual responses when tomorrow matters.

2406 LAURA ÁLVAREZ-ROMÁN, SERGIO MAYORDOMO, CARLES VERGARA-ALERT and XAVIER VIVES: Climate risk, soft information and credit supply.

2407 JESÚS FERNÁNDEZ-VILLAVERDE, JOËL MARBET, GALO NUÑO and OMAR RACHEDI: Inequality and the zero lower bound.

2408 PABLO BURRIEL, MAR DELGADO-TÉLLEZ, CAMILA FIGUEROA, IVÁN KATARYNIUK and JAVIER J. PÉREZ: Estimating the contribution of macroeconomic factors to sovereign bond spreads in the euro area.

2409 LUIS E. ROJAS and DOMINIK THALER: The bright side of the doom loop: banks’ sovereign exposure and default incentives.

2410 SALOMÓN GARCÍA-VILLEGAS and ENRIC MARTORELL: Climate transition risk and the role of bank capital requirements.

2411 MIKEL BEDAYO and JORGE E. GALÁN: The impact of the Countercyclical Capital Buffer on credit: Evidence from its accumulation and release before and during COVID-19.

2412 EFFROSYNI ADAMOPOULOU, LUIS DÍEZ-CATALÁN and ERNESTO VILLANUEVA: Staggered contracts and unemployment during recessions.

2413 LUIS FÉRNANDEZ LAFUERZA and JORGE E. GALÁN: Should macroprudential policy target corporate lending? Evidence from credit standards and defaults.

2414 STÉPHANE BONHOMME and ANGELA DENIS: Estimating heterogeneous effects: applications to labor economics.

2415 LUIS GUIROLA, LAURA HOSPIDO and ANDREA WEBER: Family and career: An analysis across Europe and North America.

2416 GERALD P. DWYER, BILJANA GILEVSKA, MARÍA J. NIETO and MARGARITA SAMARTÍN: The effects of the ECB’s unconventional monetary policies from 2011 to 2018 on banking assets.

2417 NICOLÁS FORTEZA, ELVIRA PRADES and MARC ROCA: Analysing the VAT cut pass-through in Spain using web-scraped supermarket data and machine learning.

2418 JOSÉ-ELÍAS GALLEGOS: HANK beyond FIRE: Amplification, forward guidance, and belief shocks.

2419 DANIEL ALONSO: Stabilisation properties of a SURE-like European unemployment insurance.

2420 FRANCISCO GONZÁLEZ, JOSÉ E. GUTIÉRREZ and JOSÉ MARÍA SERENA: Shadow seniority? Lending relationships and borrowers’ selective default.

2421 ROBERTO BLANCO, MIGUEL GARCÍA-POSADA, SERGIO MAYORDOMO and MARÍA RODRÍGUEZ-MORENO: Access to credit and firm survival during a crisis: the case of zero-bank-debt firms.

2422 FERNANDO CEREZO, PABLO GIRÓN, MARÍA T. GONZÁLEZ-PÉREZ and ROBERTO PASCUAL: The impact of sovereign debt purchase programmes. A case study: the Spanish-to-Portuguese bond yield spread.

2423 EDGAR SILGADO-GÓMEZ: Sovereign uncertainty.